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Silurian tentaculitids from Gotland and Scania

Kent Larsson

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Silurian tentaculitids from Gotland and Scania

KENT LARSSON

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Tentaculitids from the Silurian of Gotland and Scania, Sweden, have been examined as to their morphology, taxonomy, ecology and biostratigraphical properties. The material derives from 427 localities covering the upper Llandoverian to lower Downtonian sequence. The rich and well preserved faunas represent four families (of which Gotlandellitidae is new), nine genera (of which *Tractabilopsis* and *Gotlandellites* are new), and 44 species, 41 of which are new. Members of the family Uniconidae have not been examined. The morphology of tentaculitids is described, and several new morphological terms are introduced. Some hypotheses on their ecology, mode of life, and zoological affinity are also discussed. Their usefulness for biostratigraphical purposes is demonstrated.

Kent Larsson, Geological Survey of Sweden, Box 670, S-751 28 Uppsala, Sweden; 20th December, 1978.

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Introduction

Tentaculitoids have ever since their first illustration in literature (Walch 1775, Pl. 4: 4–5) and original description (von Schlotheim 1820) remained an enigmatic fossil group. Their mention in texts has sometimes been accompanied by brief descriptions without or with only poor illustrations, but has mostly been confined to fossil lists. A striking number of species have been described from samples geographically and stratigraphically poorly defined, including from "Silurian" erratics. This is certainly not unique to tentaculitoids, but rather is common to many of the early-described fossil invertebrates. As a consequence, many tentaculitoid species based on unreliable material have subsequently been identified from most of the Ordovician-Devonian sequence. This has contributed to the very wide stratigraphical ranges supposed for many species. Good examples of such species are *Tentaculites annulatus* von Schlotheim and *T. ornatus* Sowerby, both of which are reported to occur from Caradocian to middle Devonian strata. Most species which were erected early have, for more than a century, been used as "waste-basket" categories. It is not until the last 25 years that the excellent qualities of tentaculitoids for biostratigraphy have been proved, primarily by Ljashenko in numerous papers on the Devonian tentaculitoid faunas of Russia (Ljashenko 1953, 1954, 1956, 1957a, 1957c–d, 1966, 1967, and 1969a–d) and also, to some extent, from Late Silurian faunas in Estonia and Podolia (Ljashenko 1958).

A new era in tentaculitoid research was heralded by the paper by Ljashenko (1959) on faunas from the Russian Platform, by Bouček's (1964) paper on the thin-walled (dacryoconarid) tentaculitoids of Bohemia and in the work of Lardeux (1969) on West European and North African thin- and thick-walled tentaculitoids. In these three papers tentaculitoids are described monographically and their excellent stratigraphical properties are emphasized. Subsequent investigations have dealt mainly with Devonian faunas, from Thuringia (Zagora 1962, 1964), Harz (Zagora 1966; Alberti 1970b–c), Franconia (Alberti 1970a), North America (Ludvigsen 1972; Churkin & Brabb 1967; Churkin & Carter 1970) and Australia (Sherrard 1967, 1975). These papers have considerably increased our knowledge of the morphology, taxonomy, ecology and stratigraphical distribution of dacryoconarid tentaculitoids. The situation differs with regard to the thick-walled forms, which have so far been treated to a lesser extent (Ljashenko 1958, 1959, 1969a–c; Lardeux 1969; Hajłasz 1968, 1974). The emphasis of tentaculitoid research has been on Devonian material: Silurian tentaculitoids have only exceptionally been studied, and then only those from Late Silurian deposits (Ljashenko 1958; Hajłasz 1974).

During the systematic work on Silurian fossils of Gotland that was initiated and coordinated by Anders Martinsson within the framework of the Baltic-Scanian Silurian Project, it became obvious in the 1960s that the Silurian tentaculitoid fauna, as seen in the large collections then being surveyed primarily for palaeocope ostracodes is considerably more diverse and possesses better stratigraphical qualities than had previously been realized. Bouček's (1964) results from Czechoslovakia provided further encouragement for a study of the Silurian tentaculitoid fauna of Gotland. I was fortunate to be directed into this study in 1969, and from 1972 most of my time and efforts have been devoted to this fascinating fossil group. From 1974 this study has been performed within the auspices of Project Ecostratigraphy, for which the Baltic-Scanian Project was a "run-in" effort.

From initial studies of literature and examinations of the tentaculitoid material available in various museum collections, it very soon became evident that a fundamental revision was necessary in order to clear up the taxonomic disorder among the Silurian species already described, and that new material should be collected from exactly localised sampling spots at well-defined stratigraphical levels. It was quite clear that much of the prevailing confusion in the knowledge of the stratigraphical distribution of the tentaculitoids resulted from incomplete locality description and incorrect determination of species. The latter is understandable, considering the very brief and inadequately illustrated descriptions that have been available. Many of these descriptions were based on mould material – a fundamental error which has unfortunately been repeated even quite recently in some papers. Moreover, several papers from the last 25 years contain poor illustrations, which hamper the easy determination of tentaculitoid material.

It is my hope that this paper will present a detailed and comprehensive account of the Silurian thick-walled tentaculitoids as illustrated by material from Sweden. Special effort has been devoted to describing the morphology of these tentaculitoids and to devising a sound morphological nomenclature. Hitherto, the nomenclature has been derived from heterogeneous sources and remained very unsystematic to say the least. Discussion through the history of tentaculitoid research has centred on the zoological affinity of tentaculitoids, and, like so many other little known fossil groups, they have been shifted from phylum to phylum (including, among others, annelids, brachiopods, echinoderms and molluscs). However, this subject will only be treated briefly in this monograph. It is my firm belief that we still know too little about the morphology and ecology of tentaculitoids to comment on their affinity. Only very detailed analysis of the microstructure of their conchs, together with careful examination of their response to various environments, can contribute to a better understanding of their position in the animal kingdom. The excellent material found on Gotland and in Scania is well suited to such investigations.

The conclusions presented on morphology, ecology, geographical and stratigraphical distribution are based almost entirely on data assembled during this study of the faunas from Gotland and Scania. Only to a very small extent have observations on material from other areas (i.e. England and Estonia) been included. Although the amount of material available is immense, a complete treatment of the faunas cannot be presented in this paper. The main reason for this is the poor preservation of some tentaculitoids. This, added to a specialized morphology, makes sound taxonomic treatment very hazardous at present for members of the family Uniconiidae. Unfortunately these are also highly fragmented in most samples and it is difficult to match the pieces together reliably into taxa. Thus, these tentaculitoids will be treated only briefly, mainly in discussion of some morphological characters which are especially well seen among species of the genus *Alternatus*?. A few other tentaculitoid specimens do not fall easily into any of the taxa described here. It is difficult yet to determine whether they are varieties of known taxa or should be regarded as separate species. Such specimens are very limited in number, and I would hesitate to erect new taxa on only one or very few specimens. Apart from the groups just discussed, the entire tentaculitoid fauna, observed in the samples examined, will be described.

At this stage I think it necessary to comment on the name of the group. Hitherto, *tentaculite* (plural tentaculites) has been mostly used as an informal name comprising both thin- and thick-walled forms. The term *tentaculitid* has since the introduction of Fisher's (1962) classification been applied to thick-walled forms, also including the homoctenids, and *dacryoconarids* for thin-walled. Lardeux (1969) used "tentaculitid" to designate only the thick-walled forms. Thus several names are duplicated, and those used depend on the classification adopted.

I prefer not to use *tentaculites* because of possible confusion with the genus name *Tentaculites* von Schlotheim. I adopt the classification by Lardeux (1969) in this monograph, so I will use *tentaculitoid* as to the general name for any groups, thin- or thick-walled. *Tentaculitid* is used for any member of the order Tentaculitida, i.e. the thick-walled forms, *homoctenid* for any member of the order Homoctenida, and *dacryoconarid* for any member of the thin-walled tentaculitoids, i.e. the order Dacryoconarida.

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Many colleagues have given access to their samples from Gotland and Scania and also permitted me to describe many of their new localities. My sincere thanks for this and for stimulating companionship during field seasons on Gotland go to Dr. Michael G. Bassett, Cardiff, Dr. Stefan Bengtson, Uppsala, Christina Bengtson, Uppsala, Dr. Lennart Jeppsson, Lund and Dr. Sven Laufeld, Stockholm.

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During the final preparation of this paper I have been provided with excellent working facilities at the Section of Biostratigraphical Documentation of the Geological Survey of Sweden, Stockholm. I thank the head of the Section, Dr. Erik Norling, for this support and for his encouragement with my work.

It is with humility and pleasure that I dedicate this monograph to the memory of the late J. E. Hede. I have tried to increase understanding of the nature of the tentaculitids, to demonstrate their role in the geology of Gotland and Scania and their usefulness as stratigraphical tools in a way which I sincerely hope would fulfil his intentions. I tend to regard my contribution as completion of his work in tentaculitid research.

The paper forms a joint contribution to Project Ecostratigraphy (No. 53) and Project Tornquist (No. 86) of the International Geological Correlation Programme (IGCP).

Historical review of Silurian tentaculitoids

There have been several historical reviews of tentaculitoid research. Barrande's (1867:X–XII) classic paper gives an exhaustive summary of the state of knowledge on tentaculitoids. More recent accounts have been published by Ljashenko (1959:44–52), Fisher (1962:W99–W101), Bouček (1964:13–16), and Lardeux (1969:5–6). These works give a comprehensive account for Devonian tentaculitoid research and will not be further reviewed here. Silurian tentaculitoids, however, have been given very little attention in earlier literature, and therefore their history will be summarized in some detail, with particular emphasis on thick-walled forms. References in faunal lists will not be considered. I shall enlarge in considerable detail on the often confusing literature containing original descriptions of statements on occurrences in the areas concerned by the present investigation.

The earliest reference in literature to a tentaculitoid appears to be in the paper by Walch (1775:211–213, Pl. 4: 4–5). It is likely that at least one of the figured specimens with paired rings is of Silurian age. The genus *Tentaculites* was founded by von Schlotheim (1820), who figured and briefly described two species, *Tentaculites scalaris* and *T. annulatus,* which he regarded as forming parts of crinoid crowns. Unfortunately the syntype material was partly preserved as mould. There are numerous references to *T. annulatus* and *T. scalaris* so that wide stratigraphical ranges for these species have been supposed. Probably very few of these identifications are correct, a conclusion supported by my examination of specimens in several museum collections. Recently, Zagora (1969) redescribed von Schlotheim's material of *T. scalaris,* which was re-discovered in the Palaeontological Museum of the Humboldt University, Berlin. Zagora designated the specimen figured by von Schlotheim (1820, Pl. 29: 9b) as a lectotype (cf. Zagora 1969, Pl. 3: 3). This species is also the type species of the genus *Tentaculites* von Schlotheim. The remaining part of von Schlotheim's figured material, Pl. 29: 8a–b, was reported as lost by Zagora (1969: 222), and he considered *T. annulatus* to be a *nomen dubium.*

However, it does not follow automatically from Zagora's designation of a lectotype for *T. scalaris,* that the remaining material seen on von Schlotheim's Pl. 29: 8a–b (if it were to turn up) should be named *T. annulatus.* It is obvious from the figure that at least two species are present, the two specimens at letter *a* belonging to one species, and the single specimen *b* belonging to another. This was also pointed out by Koken (1889). Under *T. annulatus,* von Schlotheim (1820: 377) reported that two specimens, *"sehr schöne und deutliche",* derived from *Übergangskalkstein* from Gotland. These two specimens must be those figured as *a.* The specimen *b* was designated as *T. schlotheimi* much later, by Koken (1889). Unfortunately he described it very incompletely and without illustration. He regarded *T. scalaris* and *T. annulatus* as synonyms. Koken's species *Tentaculites schlotheimi* must be regarded as a *nomen dubium.* Hajłasz (1967: 551–552, Pl. 2: 6–9; Pl. 3: 10–15, Pl. 4: 16–18; Pl. 5: 20–21 and 1974, Pl. 6: 3) described a tentaculitid with a ring pattern of triplets from the Podlasian Beds in the southern Baltic coastal region and from the Gedinnian-Eifelian Stages of Poland as *T. schlotheimi.* Neither her descriptions nor illustrations prove that it belongs to *Tentaculites schlotheimi* Koken.

My investigations of the status of *T. annulatus* von Schlotheim led me to contact the Palaeontological Museum of the Humboldt University of Berlin. To my surprise, they had two pieces of limstone with tentaculitids labelled as von Schlotheim's original material of *T. annulatus,* and these were placed at my disposal by courtesy of Dr. Hermann Jaeger. The two pieces, numbered Qu.Kat.T4 p. 703, showed several tentaculitid specimens. In a letter dated 30th March 1976, Dr. Jaeger gives the following account of the derivation of the limestone pieces: "In the course of arranging the tentaculitoid collections in the museum, rock fragments with tentaculitids from von Schlotheim's collections were discovered. All pieces were accompanied with labels with the characteristic handwriting of von Schlotheim. These labels did not show any names of the fossils but only a reference to the plate and figure together with some comments that roughly agreed with the description found in von Schlotheim's *Petrefactenkunde* (1820). The limestone pieces are catalogued in F. A. Quenstedt's Catalogue which was compiled during 1833–37, i.e. immediately after the acquisition of Schlotheim's collection in 1833. The pieces carry the number Qu. Kat. T4, p. 703 and they were catalogued under the name of *Tentaculites annulatus* Schlotheim Taf. 29.8."

Comparison of the tentaculitids on the two limestone pieces with von Schlotheim's figure (1820, Pl. 29: 8) showed there to be little agreement either in the general features of the conchs or in the position and number of conchs. However, according to Dr. Jaeger (personal communication) this discrepancy is not unique, for there are several examples where von Schlotheim's originals and their illustrations are quite different.

In von Schlotheim's illustrations of *Tentaculites annulatus* the two specimens in Fig. 8*a* show an annulation of equally spaced rings separated by wide interspaces with several annulets. The specimens on the limestone pieces exhibit quite another ring pattern because the rings are clearly in pairs. von Schlotheim reports that his specimens derive from *Übergangskalkstein* in Gotland, a term, which by modern concepts would mean the entire older Palaeozoic, but the tentaculitid species on the two limestone pieces is not known in the Silurian fauna of Gotland, and the lithology differs from known rock units there. The lithology can be described as a dark, bluish-grey calcarenite, partly mixed with marl, containing a significant amount of arenaceous material and displaying the same colour. The concomitant fauna is dominated by bryozoans, but these are unfortunately indeterminable. Only one palaeocope ostracode has been found and it probably belongs to the genus *Berolinella.* This genus has not yet been described from pre-Downtonian rocks, although on Gotland representatives occur in the Sundre Beds at Hammarshagehällar 1 and probably also in the Hemse Beds at Grogarnsberget (A. Martinsson, personal communication 1976). The preservation of the single ostracode specimen is unfortunately too poor for safe identification. The remainder of the concomitant fauna consists of juvenile specimens of brachiopods which do not determine the stratigraphical level.

It seems most unlikely that these tentaculitid specimens derive from Gotland. This conclusion is supported by the following.

In 1922, Hede visited the Museum für Naturkunde in Berlin and studied the specimens just discussed. In his notes from this visit the two limestone pieces resembles closely "the slim specimen from Dudley". He continues: "If these two specimens were the originals, the figures by von Schlotheim are very much idealized. The specimen depicted as *b* is not to be seen on the hand specimens" (translated from Swedish). In my correspondence with Dr. H. Jaeger I have mentioned my doubts that the material in question derives from Gotland. In a letter dated 3rd May, 1976, Dr. Jaeger suggests that there is a possibility that this material may derive from Dudley, where von Schlotheim had obtained other fossil specimens. My own comparisons with tentaculitid material from Dudley show there to be certain similarities with the two specimens from Berlin, but as the tentaculitid fauna at Dudley is undescribed, this comparison cannot be regarded as sufficient.

In view of the large discrepancies between von Schlotheim's original description and illustration of *Tentaculites annulatus* and the specimens labelled as von Schlotheim's originals, it must be concluded that von Schlotheim's syntypes are still missing. The original description is too brief and incomplete to be used for a proper identification of the species, and consequently *T. annulatus* von Schlotheim must remain a *nomen dubium*. It would not help the nomenclature to erect a lectotype on the Berlin material while it cannot be proved beyond doubt that this is identical with von Schlotheim's original material.

The first reliable reports on the occurrence of tentaculitids on Gotland were presented by Hisinger (1827, 1828, 1831). Hisinger (1831: 122 footnote) stated that *T. scalaris* was the mould of *T. annulatus*. The first well illustrated tentaculitid from the Swedish Silurian was described by Hisinger (1837b, Pl. 35: 2) as *Tentaculites annulatus* from the Burgsvik Beds at Hoburgen on Gotland. Hisinger did not quote any author for this species, which subsequently, has been referred to Hisinger in several papers as his (e.g. Sowerby 1839; Schmidt 1859; Gürich 1896). The figured specimen has been found in the Hisinger collection at the Swedish Museum of Natural History in Stockholm. There is no doubt that this specimen (Fig. 28A) is that figured by Hisinger, because it agrees in its total length, number of rings and overall shape with the original illustrations. When compared to von Schlotheim's (1820) figures of *T. annulatus*, Hisinger's *T. annulatus* is quite similar to the two species at Fig. 8*a* in the even distribution of the rings and the wide interspace, but the proximal growth angle seems to be larger in Hisinger's specimen. As discussed previously, the name of *T. annulatus* cannot be maintained for Hisinger's figured specimen, and it is described in this paper as *Tentaculites hisingeri* n. sp.

The earliest report on tentaculitids in Scania seems to be Hisinger's (1840) record of *T. annulatus* from Klinta.

Sowerby (1839) described two new species *Tentaculites ornatus* and *T. tenuis*, from the lower Ludlovian of the Welsh Borderland and uppermost Wenlockian of Staffordshire, respectively, and these names have frequently been recorded for the tentaculitids of the Öved-Ramsåsa Beds of Scania. Sowerby's material of *T. ornatus* and *T. tenuis* was kindly made available by the Geological Museum, Institute of Geological Sciences in London. From this study it is clear that none of the two species occurs in Sweden. Sowerby gave a short generic description for *Tentaculites* and was the first to comment upon the laminated structure of the tentaculitid conch (1839: 628). It is interesting to note that he regarded Hisinger's (1837b) *T. annulatus* as a possible junior synonym of *T. ornatus*. Sowerby (1839) also recorded *T. scalaris* von Schlotheim and *T. annulatus* von Schlotheim from the Caradocian, but these identifications are most doubtful.

McCoy (1851) characterized the genus *Tentaculites* von Schlotheim and described three species, *T. annulatus* von Schlotheim, *T. ornatus* Sowerby, and *T. tenuis* Sowerby in some detail. The first description of longitudinal sculptural elements was given for *T. annulatus*. However, McCoy's determination was in fact carried out on an undescribed Caradocian species. The longitudinal elements, ribs in modern terminology, tend to be very well developed and characteristic for all late Ordovician tentaculitids and it is not so surprisingly that McCoy detected these ribs just in this species. In the description of *T. ornatus*, McCoy mentioned a further species, *T. striatocostatus*, recorded as having been named by a Count Münster for specimens resembling *T. ornatus*. As neither description nor illustration of this species can be found in the literature this name must be regarded a *nomen nudum*. Judging from the specific name, it would have been founded on Ordovician material.

Bronn (1851–1856) examined the wall structure of the tentaculitoid conch and pointed out the obvious dissimilarities between the structures of tentaculitoids and crinoids (1851–1856: 439). He noted similarities to pteropods, especially the horny lustre of the conchs in the two groups. He also remarked upon the occurrence of oblique rings in the tentaculitids (1851–1856: 440). Quenstedt (1852) gave a brief account of tentaculitids from Silurian erratics and figured specimens described as *Tentaculites scalaris* von Schlotheim, *T. annulatus* von Schlotheim, and *T. ornatus* Sowerby. This paper is of special interest because one may assume that Quenstedt based his discussion on von Schlotheim's material which he had by then obviously curated (see p. 5 herein). The fact that he described (Quenstedt 1852: 391) and illustrated (1852, Pl. 35: 29) *T. annulatus* as having paired rings, a feature which cannot be deduced from von Schlotheim's description or figures, supports this assumption. The close affinity to *Tentaculites ornatus* Sowerby was emphasized. *Tentaculites scalaris* (Quenstedt 1852, Pl. 35: 26–28) was reported to occur concomitantly in the same boulder material. Quenstedt paid special attention to the characters of the mould of the living chamber (1852, Pl. 35: 28), and he arrived at the conclusion that the animal moved its soft parts in a distal direction during its growth. In a later edition of Quenstedt's paper (1867) the illustrations of *T. scalaris* had been somewhat changed, and the conchs in Figs. 27a–b show markedly curved proximal parts. However, this difference was not commented upon in the text.

Material from erratic boulders of Silurian age was also examined by Boll (1856), who recorded a species with rings in pairs as *Tentaculites ornatus* Murchison. It is notable that he regarded *T. scalaris* von Schlotheim as the mould of this species. Boll also introduced a new species, *Tentaculites curvatus,* for some other tentaculitids from the same boulders. This species was described as having a rapidly expanding conch with prominent, regularly spaced rings and a slightly curved proximal part. Unfortunately, the species was not illustrated, and no syntypes have been traced in spite of inquiries to several museums. The name is herein regarded a *nomen dubium.* Zagora (1969) regarded this species as synonymous with *Tentaculites scalaris* von Schlotheim, which possesses a fairly curved proximal part. I would tend to agree with this diagnosis. The stratigraphical level seems to be the same because in both cases the tentaculitids are reported to be associated with *Nodibeyrichia tuberculata.* This would then suggest a Podlasian age of the material (cf. Tomczykowa & Witwicka 1974).

Schmidt (1858) mentioned some Silurian tentaculitids from Estonia. He reported *Tentaculites annulatus* von Schlotheim from the Jaani and Ohesaare Beds and *T. ornatus* from the Jaani Beds. One species, *Tentaculites inaequalis* Eichwald, was mentioned from Ohesaare and it was compared to Quenstedt's (1852) figure of *T. annulatus.* It should be mentioned, though, that *T. inaequalis* was not described by von Eichwald until 1860 (d'Eichwald 1860), and then as *Lonchidium inaequale.* Schmidt (1859) reported two species, *T. annulatus* Hisinger *and T. inaequalis,* from Gotland. *T. annulatus* was mentioned from Näs (1859: 439), Närshamn (1859: 444), and Katthammarsvik (1859: 448). The species was referred to as characteristic for the "Conglomerate Beds", i.e. the Burgsvik Beds. *Tentaculites inaequalis* was mentioned from Grötlingbo (Schmidt 1859: 442), Närshamn (1859: 444), and Katthammarsvik (1859: 448). For both species, Schmidt concluded that they were characteristic of the Ludlovian of Gotland.

In 1859, Boll described a new species, *Tentaculites walchii,* from erratic boulders (Boll 1859). Boll stated (1859: 163) that this species was conspecific with Walch's (1775, Pl. 4: 5) tentaculitid species with rings in pairs. Boll's description is very incomplete and lacks any illustration. Neither has the original material been located so the name is considered a *nomen dubium.* Krause (1877) noted this species to be a synonym of *T. inaequalis* Eichwald. Boll (1859) also mentioned *T. curvatus* Boll and *T. annulatus* von Schlotheim?. It is clear that Boll recognized the taxonomy of the latter species to be unstable from his remarks that several species had been described under the name of *T. annulatus* (1859: 163).

As already mentioned, d'Eichwald (1860) introduced a new genus, *Lonchidium.* He distinguished this genus from *Tentaculites* by stating that *Lonchidium* belonged to the pteropods, but *Tentaculites* represented parts of crinoidal arms or to spines of productid brachiopods (1860: 1041). He described one new species with rings in pairs, *Lonchidium inaequale,* from Late Silurian beds on Ösel, Estonia, and at Kamenets-Podolsk in Podolia. Two other species with regularly spaced rings, *L. aequale* and *L. approximatum,* were described from the Devonian of the Caucasus, from material figured and briefly described by Abich (1850). von Eichwald's generic name *Lonchidium* has only very rarely been used but, rather, his species have been referred to *Tentaculites* von Schlotheim (cf. Ljashenko 1958: 26). Karsten (1869) used both names, writing *T. (Lonchidium) inaequalis* Eichwald in the text (1869:39), but *Lonchidium (Tent.) inaequale* Eichwald in the caption to Table 12: 7. The dismissal of von Eichwald's generic name is not easily understandable because the name is valid. No type species has been designated to von Eichwald's genus. The species described as *Lonchidium inaequale* definitely cannot be included in *Tentaculites,* and the other two species referred to *Lonchidium* differ conspicuously from *L. inaequale* and belong either to *Tentaculites* or some other closely related genus. I am designating herein (p. 86) *Lonchidium inaequale* as the lectotype of the type species of *Lonchidium* d'Eichwald. The emended generic diagnosis is given in the systematic part of this paper. *Lonchidium inaequale* d'Eichwald, like *Tentaculites scalaris* von Schlotheim (= *T. estonicus* Ljashenko), is characteristic of the Ohesaare Beds of Ösel, Estonia. The genus is also well represented on Gotland and in Scania.

In several of the papers mentioned previously, the question of the zoological affinity of the tentaculitoids was discussed. In the earlier works, tentaculitoids had been referred to a number of different phyla. von Schlotheim (1820) had regarded his two species *T. scalaris* and *T. annulatus,* as parts of crinoid crowns. The same two species were considered by Hisinger (1827) to have been annelids or terebratulid brachiopods. The latter opinion was shared by Klöden (1834: 181, 183). However, Hisinger later (1837a: 1077) changed his mind and was more inclined to regard both species as spines of *Echinus gyracanthus* Eaton. However, by the second half of the 19th century the idea of affinity with pteropods seems to have become firmly established. Following Austin (1845), McCoy (1851) attributed the tentaculitoids to the pteropods, an assignment which was supported by Bronn (1851–1856). A pteropod affinity was clearly emphasized in two papers by Nicholson (1872a, b). The straight, conical shape of the tentaculitoid conch and its free mode of life were criteria he pointed to as support for this theory.

A different opinion was published by Vine (1882), who regarded the tentaculitoids as belonging to annelids. He redefined the genus *Tentaculites,* emphasizing particularly the lack of longitudinal morphological elements and cellular structure of the conch, in contrast to the genus *Cornulites.* That tentaculitids lived unattached was stressed. Vine also defined some morphological elements of the conch (1882:379). Three new tentaculitid taxa were introduced, *Tentaculites wenlockianus* from the Wenlockian of Shropshire and *T. multiannulatus,* with *T. tenuis* Sowerby var. *attenuatus,* from the basal Ludlovian of

Shropshire. Because of their stringency, these descriptions contrast considerably with previous descriptions of tentaculitids. Records of *T. ornatus* Sowerby were given, and Vine pointed out some similarities between this species and *T. annulatus* as described by Hisinger (1837b). Vine's species belong to those Silurian tentaculitids which have frequently been reported from various parts of the Ordovician-Devonian sequences. Vine's figures of *T. wenlockianus* (1882, Pl. 15: 5, 6, 11–13) and *T. multiannulatus* (1882, Pl. 15: 7) show only small fragments of the conchs, which partly explains the many misidentifications in subsequent literature. Even in Vine's original collection of tentaculitids, kept at British Museum (N.H.) in London, there are several species mixed under the same name in the same slides. Thus, it cannot be deduced from these slides which of the specimens should be considered types of the species, especially as the various conch fragments are poorly preserved and show little agreement with the published figures. To provide a satisfactory basis for designation of lectotypes among this material, it is necessary to make new collections from Vine's type localities, in order that different, if closely related, species will not be mixed under one name. This applies particularly to the tentaculitids which Vine described as *Tentaculites multiannulatus* but which could undoubtedly include several species. Vine's material of *T. wenlockianus* was examined, and it is concluded that this species does not in fact occur on Gotland or in Scania, despite the many records of it in the literature. Whether the species described as *T. multiannulatus* occurs on Gotland is uncertain but the genus to which it belongs, probably *Alternatus* Ljashenko, is well represented through the sequence.

Occurrences of Silurian tentaculitids in North America were treated comprehensively by Hall (1879). Notes and descriptions of thick-walled tentaculitoids had been given previously in a number of papers, such as Vanuxem (1842), Mather (1843), Hall (1843, 1847, 1852), Meek & Worthen (1865), Nicholson & Hinde (1874). Most of the species described in these papers were considered by Hall (1879, 1888) to be cornulitids. Some of the occurrences reported from the Silurian are now referred to the Devonian. *Tentaculites minutus* Hall from the Rochester Shale, *T. niagarensis* Hall and *T. neglectus* Nicholson & Hinde from the Clinton Group remain unquestionably Silurian species. Unfortunately, practically nothing of importance has been published on North American tentaculitids since Hall's days, and consequently there is a large gap in our knowledge of the faunas. The published figures and descriptions do not permit closer comparison between the North American species and those described from Gotland and Scania. Although some North American species have been reported from Gotland, e.g., by Chapman (1901), such observations cannot be corroborated in the present paper.

The first account of the microstructures of the tentaculitid conch was given by Dewitz (1883). He based his investigations on a species identified as *Tentaculites ornatus* Sowerby and found in erratic boulders in East Prussia. Dewitz' material should most likely be referred instead to *Tentaculites scalaris* von Schlotheim. Dewitz made observations on the morphology and microstructures of the conch wall and drew attention to small dark canals he believed to penetrate partly the conch wall. These "canals", which have been demonstrated to be optical phenomena (Blind 1969) have subsequently been regarded as an important taxonomic character (e.g., Ljashenko 1959; Sherrard 1967).

In the first half of this century there were only a few new Silurian tentaculitids described and very few contributions made to the knowledge of their morphology. It is not until Ljashenko's pioneer works on the tentaculitoids, the first of which was published in 1953, that new data emanated on this fossil group. However, there had been numerous references to occurrences of tentaculitids in Silurian strata. The following account deals only with those for Swedish Silurian beds, and includes the various notes from the later part of the 19th century.

As already mentioned, Hisinger (1827, 1828, 1831, 1837a, b and 1840) was the first scientist to prove the presence of tentaculitids in Sweden. The earlier note by von Schlotheim (1820) of *Tentaculites annulatus* from Gotland cannot be confirmed. Schmidt (1859) was the next to contribute to the knowledge of the tentaculitid fauna of Gotland. Lundgren (1874, 1877), Linnarsson (1875) and Tullberg (1882a) mentioned *T. tenuis* Sowerby from Klinta, Bjärsjölagård and Ramsåsa in Scania. Subsequently, Eichstädt (1888) recorded *T. tenuis* Sowerby and *T. ornatus* Sowerby from the same areas. These two species were also recorded by Grönwall (1897) from the principal areas in Scania with late Silurian rocks. The extensive faunal lists accompanying his records make this paper still a key reference for the Öved-Ramsåsa Beds in Scania. Chapman (1901) recorded a tentaculitid fauna from the Mulde brickyard on Gotland. The species listed were *Tentaculites elongatus* Hall, *T. tenuis* Sowerby, *T. wenlockianus* Vine, *T. ornatus* Sowerby, and *T. multiannulatus* Vine. The present study has not confirmed the presence of any of these species at that locality or indeed anywhere else on Gotland. Munthe (1902) mentioned *T. annulatus* von Schlotheim from the Lau area on Gotland. Törnebohm & Hennig (1904) recorded *T. tenuis* Sowerby from Klinta. A new locality and stratigraphical horizon with tentaculitids in Scania was described by Moberg & Törnqvist (1908), who mentioned *T. tenuis* from Lerberget at Röddinge in beds belonging to the *Cyrtograptus* Shale. These tentaculitids are described as *Dicricoconus tenuissimus* (Hede) in the present paper. Moberg & Grönwall (1909: 8–46) encountered the youngest occurrence so far of tentaculitids in Sweden, from the Ramsåsa area in Scania where *T. tenuis* Sowerby and *T. annulatus* were recorded from several localities. For the first time these authors gave a rather full description of Swedish tentaculitids, with important notes on their morphology and a discussion of terminological matters (1909:46–47). Of special interest is their discussion on the numerous misidentifications of tentaculitid species in previous literature. Unfortunately, they themselves did not succeed too well at identifying their material, as may be seen from their collections housed at the Palaeontological Department in Lund. In their historical survey, they regarded von Schlotheim's material of *Tentaculites scalaris* as having been derived from Gotland. Further, they pointed out the presence of Devonian species among von Schlotheim's specimens described as *Tentaculites annulatus. Tentaculites ornatus* Sowerby is stated to be conspecific with *T. annulatus* described and figured by Hisinger (1837b), to which description they added some characters. They were inclined to regard *T. ornatus* Sowerby as an end member of the specific variation of *T. tenuis* Sowerby. In addition, *T. inaequalis* d'Eichwald was considered to belong to *T. tenuis.* Their assumptions cannot be corroborated by the present study.

van Hoepen (1910) reported *T. wenlockianus* Vine and *T. multiannulatus* Vine from Mulde Tegelbruk 1, although no descriptions of the species were submitted. Hede (1915, Pl. 3: 13) figured and described as *Tentaculites* sp. a minute bent shell from the basal *Colonus* Shale at Smedstorp, Scania, however, the state of preservation of the material does not permit such a designation. In additional material collected from that locality, no shells of this shape have been encountered but minute pyritized orthoconic nautiloids are abundant.

In Hede's subsequent papers on the Silurian of Gotland and Scania, tentaculitids are frequently recorded and, in two cases, also described. *Tentaculites wenlockianus* Vine was described by Hede (1917) from a locality south of Klintehamn, Gotland, in beds now referred to as the Slite Beds. In the present paper this tentaculitid is described as *Dicricoconus clintianus.* Hede (1919a) briefly described a minute species, *Tentaculites* n. sp. in a footnote, but did not figure it. The species was recorded from a number of localities along the west coast of the Näs peninsula. The present study has proved this species to be conspecific with *Dicricoconus tenuissimus* (Hede). The same species was described in Hede (1919b: 129–130, Pl. 5: 6) from the *Colonus* Shale at Skarhult, Scania. Another species, *Tentaculites* cf. *ornatus* Sowerby was also mentioned from this locality. It is described herein as *Odessites geretiensis.* In his description of the Burgsvik borehole, Hede (1919c) logged several tentaculitids in the core sequence. *Tentaculites inaequalis* d'Eichwald and *T. ornatus* Sowerby were recorded from the Burgsvik Beds and *Tentaculites* n. sp. from the Hemse Beds. These tentaculitids are described as *Odessites portensis, Tentaculites hisingeri* and *Dicricoconus tenuissimus,* respectively, in this paper.

In the classical account by Hede (1921) of the geology of Gotland, the stratigraphical significance of the tentaculitids was clearly demonstrated. Tentaculitids were recorded through the Tofta Beds up to the top of the Hamra Beds. Hede noted six new species designated *Tentaculites* n. sp. 1–6, *T. multiannulatus* Vine, *T. wenlockianus* Vine, *T. annulatus* Schlotheim, and *T. inaequalis* d'Eichwald. Hede (1925a) added *T. scalaris* Schlotheim to the species listed above. This species, which was reported from the Burgsvik Beds, probably corresponds to *T. hisingeri* as described here. In the descriptions accompanying the geological map sheets of Gotland (Munthe 1921b; Hede 1925b, 1927a, 1927b, 1928, 1929, 1933, 1936, 1940), all the species mentioned above were recorded from many localities. Not until recently, when Hede's collection of tentaculitids became accessible, was it possible to check Hede's identifications. Although the specific names are incorrect for the Gotland tentaculitids and within the species named were also included several other species, Hede's range chart (1921, Pl. 1) gives a good indication that tentaculitids could be useful for vertical zonation.

Since Hede's papers mentioned above, few notes on the distribution of Swedish tentaculitids have been published, and no further species have been recorded. The species reported in later papers are merely repeated from earlier literature; e.g. in Hede (1958) when *T. inaequalis* and *T. scalaris* were recorded from the Öved-Ramsåsa Beds in Scania and in Hede (1960) when some occurrences of tentaculitids on Gotland was reported.

Swedish tentaculitid material was used by Bøggild (1930, Pl. 13: 2), who demonstrated the lamellar, calcitic structure of the conch. Fisher (1962, Fig. 55) figured tentaculitids from Mulde, and Blind (1969) obviously based his work mainly on Scanian material but without giving any information on sampled localities or stratigraphical levels.

In this context some words must be mentioned about Hede's tentaculitid studies.

The late J. Ernhold Hede's interest in tentaculitids was not confined to the listing of various species at different localities. He started early on to investigate this group in detail and obviously planned a monographic description of the Silurian tentaculitids from Gotland and Scania. There have been found vast collections, notes, thin-sections, figured specimens and mounted plates which he kept in his office at the Palaeontological Department in Lund. Most of the laboratory work preliminary to the compilation of manuscript seems to have been finished in the early 1940s. For some reason the work ceased. Early in my research I was informed about Hede's interest in tentaculitids, but unfortunately I did not get the chance to examine his material nor for discussion with him. Not until December 1977 did I get access to Hede's collections, through the courtesy of Professor G. Regnéll. The material is extremely comprehensive, and I have by no means been able to check it all fully. However, I found no indication that I have overlooked taxa, obtained incorrect ranges for the species or missed important facies. On the contrary, his material chiefly supports my own results. The difference between Hede's material and my own lies in the state of preservation and the origin of the samples. Hede mainly collected well-consolidated slabs with more or less intact tentaculitids, while I mostly used marl samples with a fairly high percentage of broken conchs. In some cases it has been desirable to use his material as type material. Some of Hede's drawings and thin-sections are included in the present paper. The generally excellent quality of Hede's tentaculitid material from many localities not visited for this study makes it highly valuable for future studies of the tentaculitid faunas of Gotland and Scania. Hede's collection of tentaculitids from other areas, such as Norway, England and North America, has been important for reference purpose in the present study.

It was stated at the beginning of this chapter that the modern phase in tentaculitoid research was initiated by Ljashenko in her 1953 paper. Her many papers provide a modern and comprehensive description of the morphology, taxonomy, ecology and stratigraphy of principally Devonian tentaculitoids, both thick- and thin-walled. We owe much of our present knowledge of tentaculitoids to her contributions, and for understanding of tentaculitoid morphology and systematics her papers of 1956, 1957b, 1957c, 1959 and 1969a–d are indispensable. In Ljashenko (1958), *T. ornatus* Sowerby, *T. nikiforovae* n. sp., *T. gyracanthus* (Eaton), *T. russiensis* n. sp., *T. estonicus* n. sp. and *T. inaequale* (Eichwald) were described from the Silurian of Estonia and Podolia. In her paper (1969a) more Silurian tentaculitids, *Podolites rugosus* n. sp., *Sokolites zagora* n. sp. and *Parvulites raschkovensis* n. sp., were described. In her 1969 papers several new tentaculitoid genera were established. It is questionable whether all these new genera can be justified because for several no generic diagnoses were given nor have appeared since. Some of these new genera are probably junior synonyms of previously described tentaculitoid genera.

A general account of the morphology, palaeoecology and classification of tentaculitoids was given by Fisher (1962). He introduced a new class, Cricoconarida, to include tentaculitids, nowakiids and styliolinids. Two orders were distinguished: Tentaculitida for the thick-walled forms, and Dacryoconarida for the thin-walled forms.

In 1964, Bouček produced a monograph of the Devonian tentaculitoids of Bohemia (Bouček 1964). The monograph is also comprehensive on the general morphology, palaeoecology and classification of tentaculitoids. Thus, although no Silurian or thick-walled tentaculitoids were described, many of Bouček's statements are relevant to the present study. Another key reference for all tentaculitoid studies is the monograph by Lardeux (1969). He also limited his study mainly to Devonian material, but his treatment of the morphology of thick-walled tentaculitids was indispensable for the present study where his taxonomic scheme has been largely adopted. Lardeux figured and described two Silurian species, *Tentaculites ornatus* Sowerby (1969: 42–43, Pl. 14: 1–3; Figs. 25–26) and *T. tenuis* Sowerby (1969: 53, Pl. 13: 5–6), and important notes on *T. scalaris* von Schlotheim and the questionable species *T. schlotheimi* Koken (1969: 46) were given.

Blind (1969) introduced a new hypothesis when he referred the tentaculitids to the molluscs, close to the cephalopods. The inferred relationship to molluscs was largely based on the assumed discovery of an operculum covering the apertural end of a tentaculitid which was obtained from some undescribed locality in Scania or on Gotland. SEM studies of the conch wall also contributed to Blind's placing of the tentaculitids among the molluscs. His interpretation has subsequently been accepted by other authors, e.g. Hajłasz (1971) and Brassel *et al.* (1971). In a recent paper, Blind & Stürmer (1977) maintained the idea of a close relationship to the cephalopods, and they also described some structures believed to be remnants of soft tissues. Blind's hypotheses are undoubtedly based on weak evidence and will be commented upon further in later chapters.

Recently, thick-walled tentaculitoids have played a more dominant role in stratigraphical accounts from Europe. Hajłasz (1968) described a number of tentaculitids from Lower Devonian strata in a borehole in central Poland, and subsequently (1974) presented a large work on late Silurian-Devonian tentaculitoids taken from abundant subsurface material in Poland. In the latter work (Hajłasz 1974) the late Silurian (Podlasian) species described were ?*Tentaculites schlotheimi* Koken, *T. scalaris* Schlotheim, *T. inaequalis* (Eichwald), *T. tenuis* (Sowerby), *T. lebiensis* Zagora, *T. abnormis* n. sp. and *Tentaculites* sp A. Some of these determinations are undoubtedly incorrect. A remarkable occurrence of *Nowakia* sp. and *Viriatellina* sp. was also reported from these beds.

Zagora's (1969) revision of *Tentaculites scalaris* von Schlotheim was very welcome and is of great importance for the stability of tentaculitid taxonomy. In 1972 he described a new species, *Tentaculites lebiensis,* from late Silurian beds in the borehole Łeba 1 (Zagora 1972). Several species were subsequently described (Zagora 1974) from museum collections which partly derived from Gotland. These species included *Podolites peregrinus* n. sp., *Odessites* cf. *tenuis* (Sowerby), *Alternatus multiannulatus* (Vine), *Tentaculites* n. sp. A, *Tentaculites* n. sp. B, *Tentaculites* n. sp. C, and *T. wenlockianus* Vine. Most of his figured species occur on Gotland, except for *Podolites peregrinus* n. sp., but none of the names can be retained and the rest belong to hitherto undescribed species.

Outside Europe there have been few recent studies on Silurian tentaculitid faunas. In Australia, Sherrard (1967) described a fauna from New South Wales which included species referred to as *Tentaculites ornatus* Sowerby and *Volynites russiensis* (Ljashenko). Important notes on their classification and ecology were given.

The ecology of tentaculitids has received little attention in the previous literature. The few notes available derive from discussions on the affinity of the tentaculitoids, e.g. Fisher (1962), Blind (1969), Berger (1974) gives a lengthier account based on observations of material collected in Podolia. Some of his theories are disputable. Erdtmann & Yoder (1974) and Yoder & Erdtmann (1975) lodged an entirely new hypothesis on tentaculitids when they inferred a dimorphism among the Devonian species *Tentaculites bellulus* Hall and *T. attenuatus* Hall. This is a controversial theory based on ratios computed from disputable measurements of ring sizes. However, their papers form a most welcome first contribution to the revision of the North American tentaculitoid faunas.

Geology of the areas

Gotland

An excellent review of the geology of Gotland was presented by Laufeld (1974b: 7–13), and no new observations have emerged from the present investigation which could revise this concept of the geology. On the contrary, the tentaculitid faunas largely corroborate the stratigraphical scheme outlined in Hede's many papers and the results of the studies on palaeocope ostracodes (Martinsson 1962, 1967) and chitinozoans (Laufeld 1974b). The stratigraphical distribution of these three fossil groups and the zonations that may be deduced from them are not identical. Discrepancies certainly relate to differences in palaeoecology and groupings of appearances and extinctions. One of the intentions behind the current investigations on Gotland is to arrive at a revision of the stratigraphical subdivision of the Silurian sequence of Gotland, and yet not to anticipate this by stratigraphies based on ranges within a single phylum. The current concept of the stratigraphic division of the Silurian of Gotland is shown in Fig. 1.

Scania

A review of the Silurian of Scania was presented by Regnéll (1960). Much important new information has emerged since then (e.g., Martinsson 1967; Jeppsson 1974; Laufeld *et al.* 1975) that partly modifies partly corroborates earlier findings. A new detailed review of the Silurian stratigraphy of Scania will be given. This is important for understanding the distribution of tentaculitids in various facies and their responses to different ecological parameters. It will make easier the comparison with the tentaculitid occurrences in the Silurian of Gotland that appear in later chapters of this paper. The following account is slightly biased towards the late Ludlovian–early Downtonian parts of the sequence because these parts have yielded the Scanian tentaculitid faunas described here.

The Silurian of Scania comprises the whole system, from the base to the top. It is traditionally divided into four units: in ascending order, the *Rastrites, Cyrtograptus, Colonus* and Öved-Ramsåsa Beds, generally referred to as lithostratigraphical units, e.g., the *Colonus* Shale (Fig. 1). This is not a subdivision satisfying modern concepts and needs, as has been pointed out by several authors (Waern 1960: 127; Regnéll 1960: 26, 29; Laufeld *et al.* 1975: 208). None of the index graptolites of the lower three units has an adequate vertical range, and also these graptolites occasionally occur very rarely. Waern (1960) advocated abandoning the term *Rastrites* Shale, and therefore introduced four stages for the Llandoverian part of the sequence: in ascending order, the Bollerup, Silvberg, Klubbudden and Kullatorp Stages. The *Cyrtograptus* and *Colonus* Beds still await division into stages.

There are several reasons why the Silurian of Scania is known in less detail than the corresponding sequence of Gotland. The most important is undoubtedly the tectonic deformation in Scania, which is responsible for parts of the sequence being unaccessible, and has given a "spotty" appearance to the bedrock. The sequence is mostly concealed by a thick overburden of Quaternary deposits. For this reason the outcrops are few and widely scattered. Besides, the Silurian lithologies of Scania, which are predominantly in shale and mudstone facies in the Llandoverian, Wenlockian and most of the Ludlovian, the great thicknesses of some series and the facies-control evident in the faunas, make the Scanian Silurian somewhat less suitable for detailed studies than Gotland.

The Silurian of Scania is mainly composed of graptolitic shales except for the very top of the sequence, where mudstones, marlstones, limestones and sandstones predominate. A detailed correlation with the carbonate sequences of Gotland has been difficult but during the last decades, new data have emerged primarily from studies on palaeocope ostracodes, chitinozoans and conodonts, and consequently the chances of correlations have improved, especially in the youngest part of the sequence.

Our knowledge of the Llandoverian and Wenlockian of Scania is based on numerous papers published some hundred years ago (Tullberg 1882a, 1882b, 1883; Törnqvist 1875, 1913). Similarly with the upper Ludlovian–lower Downtonian strata, the Öved-Ramsåsa Beds were treated comprehensively by Eichstädt (1888), Grönwall (1897) and Moberg & Grönwall (1909). All these students had the advantage of localities being much more accessible than they are today. Modern works on the late Silurian sequence include the papers by Martinsson (1962, 1967) on palaeocope ostracodes, Mori (1969) on stromatoporoids, and Jeppsson (1974) on conodonts. The last paper also gives an account of the palaeogeographical setting of the area and the nature of sedimentation of the Öved-Ramsåsa Beds. Research on the two lowermost units was reviewed by Laufeld *et al.* (1975), who also designated the boundary between the *Cyrtograptus* and *Colonus* Shales.

Silurian rocks in Scania occur in a diagonal strip striking NW–SE and situated within the intracratonic Oslo–Scania–Baltic depression (Størmer 1967: 209–210, Figs. 21–22). More precisely, the Silurian forms the principal bedrock surface in the central part of Scania. It occurs in a 10 to 15 km wide and 100 km long zone extending from the Simrishamn area in the south-east to the area south of Söderåsen in the north-west, where it dips beneath Mesozoic rocks and then reappears in a limited area at Nyhamnsläge (Fig. 2). Silurian rocks are also exposed on the north-western slope of Romeleåsen in the Lund area. In subsurface investigations, Silurian shales have been recorded in several deep wells to the south-west of a line Malmö–Smygehuk in southernmost Scania. The top of the Silurian in the wells drilled here occurs at depths varying from 1719 to 2148 m below sea-level. Between the Malmö–Smygehuk line and Romeleåsen, Palaeozoic rocks seem to be mostly or entirely missing; this has been indicated by extensive seismic investigations and by four deep wells in which Mesozoic rocks were found to rest directly on the Precambrian basement.

Faulting has played an important role in the distributional pattern of the Silurian as well as the earlier Palaeozoic rocks. In the subsurface rocks of south-western Scania, the general tectonic picture is a series of faulted blocks displaced along NW–SE and NNE–SSW lines and tilted in various directions. This tilting has

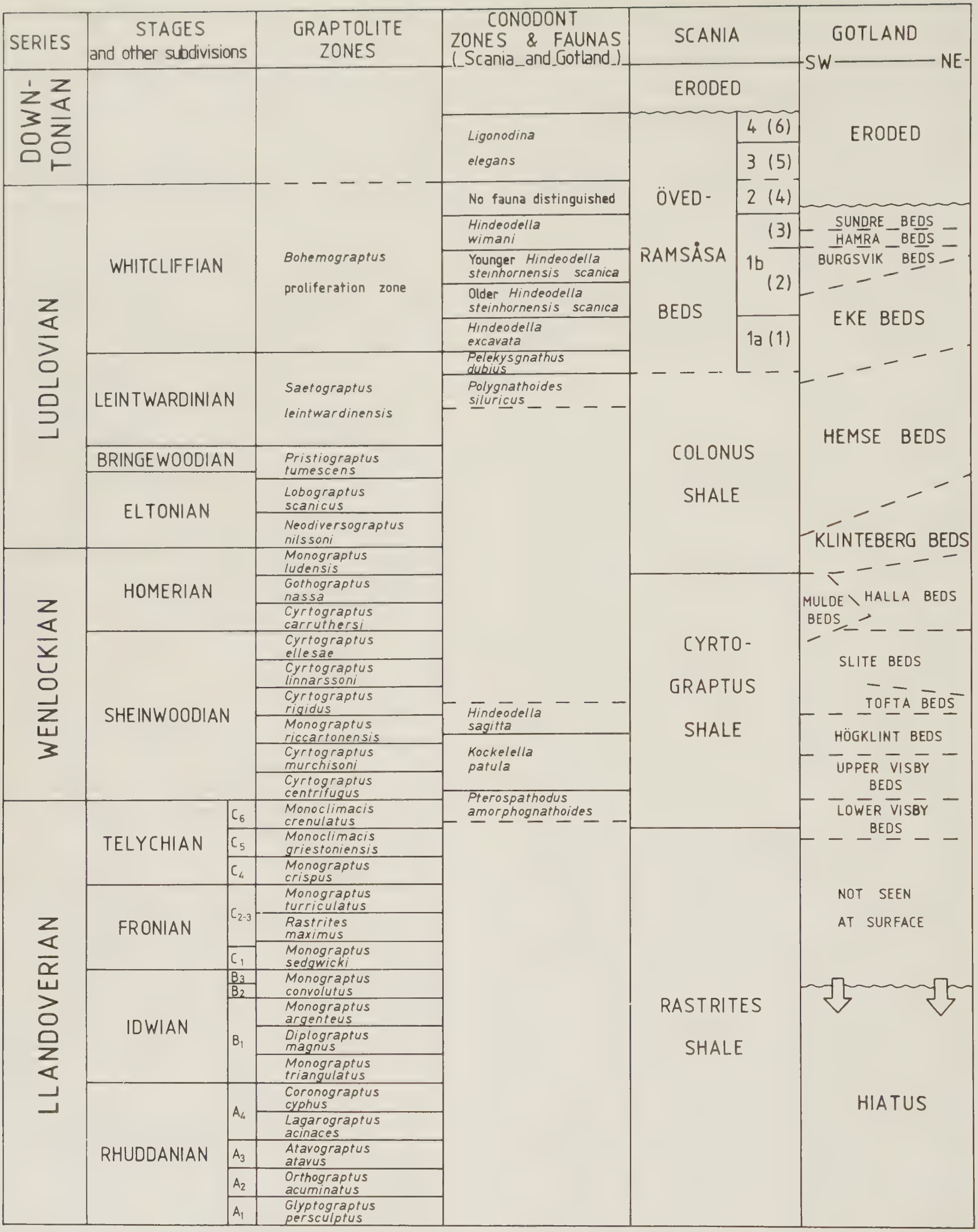

SERIES
STAGES and other subdivisions
GRAPTOLITE ZONES
CONODONT ZONES & FAUNAS (Scania and Gotland)
SCANIA
GOTLAND
SW
NE
DOWNTONIAN
LUDLOVIAN
WENLOCKIAN
LLANDOVERIAN
WHITCLIFFIAN
LEINTWARDINIAN
BRINGEWOODIAN
ELTONIAN
HOMERIAN
SHEINWOODIAN
TELYCHIAN
FRONIAN
IDWIAN
RHUDDANIAN
C6
C5
C4
C2-3
C1
B3
B2
B1
A4
A3
A2
A1
Bohemograptus proliferation zone
Saetograptus leintwardinensis
Pristiograptus tumescens
Lobograptus scanicus
Neodiversograptus nilssoni
Monograptus ludensis
Gothograptus nassa
Cyrtograptus carruthersi
Cyrtograptus ellesae
Cyrtograptus linnarssoni
Cyrtograptus rigidus
Monograptus riccartonensis
Cyrtograptus murchisoni
Cyrtograptus centrifugus
Monoclimacis crenulatus
Monoclimacis griestoniensis
Monograptus crispus
Monograptus turriculatus
Rastrites maximus
Monograptus sedgwicki
Monograptus convolutus
Monograptus argenteus
Diplograptus magnus
Monograptus triangulatus
Coronograptus cyphus
Lagarograptus acinaces
Atavograptus atavus
Orthograptus acuminatus
Glyptograptus persculptus
Ligonodina elegans
No fauna distinguished
Hindeodella wimani
Younger Hindeodella steinhornensis scanica
Older Hindeodella steinhornensis scanica
Hindeodella excavata
Pelekysgnathus dubius
Polygnathoides siluricus
Hindeodella sagitta
Kockelella patula
Pterospathodus amorphognathoides
ERODED
ÖVED-RAMSÅSA BEDS
4 (6)
3 (5)
2 (4)
(3)
1b
(2)
1a (1)
COLONUS SHALE
CYRTOGRAPTUS SHALE
RASTRITES SHALE
ERODED
SUNDRE BEDS
HAMRA BEDS
BURGSVIK BEDS
EKE BEDS
HEMSE BEDS
KLINTEBERG BEDS
MULDE BEDS
HALLA BEDS
SLITE BEDS
TOFTA BEDS
HÖGKLINT BEDS
UPPER VISBY BEDS
LOWER VISBY BEDS
NOT SEEN AT SURFACE
HIATUS

Fig. 1. The Silurian stratigraphy of Gotland and Scania, and the correlation with the standard British graptolitic and shelly successions. Mainly after Martinsson 1967 (Gotland, Scania), and Laufeld *et al.* 1975 (Scania); conodont zones from Jeppsson 1974 and 1979. Minor breaks in the sequence are not indicated. Numerical subdivisions of the Öved-Ramsåsa Beds from Grönwall 1897 (left) and Eichstädt 1888 (right).

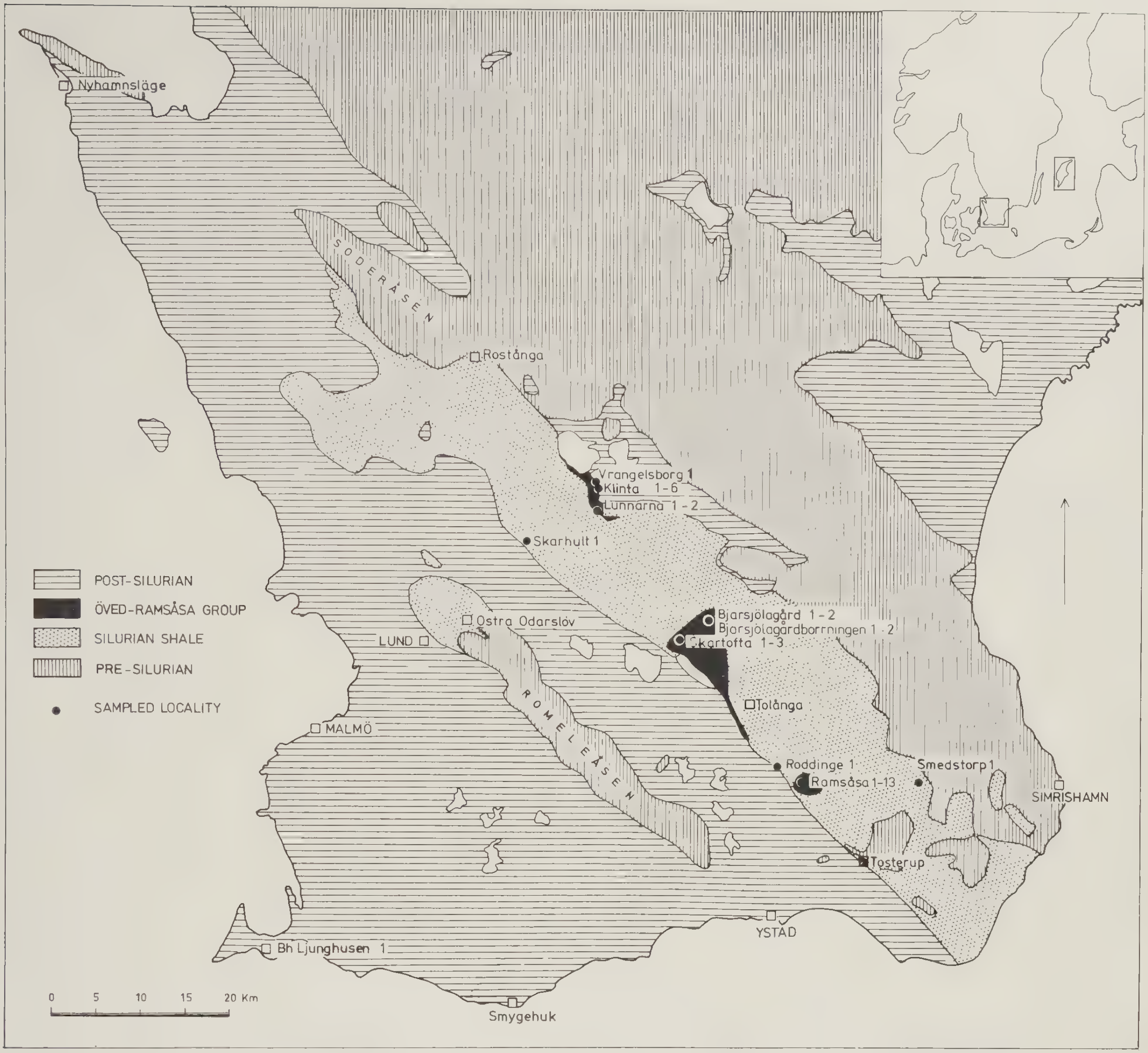

Nyhamnsläge
SÖDERÅSEN
Rostånga
Vrangelsborg 1
Klinta 1-6
Lunnarna 1-2
Skarhult 1
POST-SILURIAN
ÖVED-RAMSÅSA GROUP
SILURIAN SHALE
PRE-SILURIAN
SAMPLED LOCALITY
Östra Odarslöv
LUND
Bjärsjölagård 1-2
Bjärsjölagårdborrningen 1-2
Skartofta 1-3
Tolånga
MALMÖ
ROMELEÅSEN
Röddinge 1
Smedstorp 1
Ramsåsa 1-13
SIMRISHAMN
Tosterup
YSTAD
Bh Ljunghusen 1
0 5 10 15 20 Km
Smygehuk

Fig. 2. Simplified geological map of Scania showing the sample localities (filled circles) with their code names, and additional localities which are discussed in the text (open squares). For description of localities, see Appendix.

resulted in the different amounts of erosion of the upper Silurian which can be clearly seen in the sections penetrated by deep wells. This tilting and erosion must have occurred in late Palaeozoic time because there are more or less horizontal Mesozoic rocks which rest discordantly on various parts of lower Palaeozoic rocks or on the crystalline basement. The age of the youngest Silurian beds from the deep wells is not precisely known because of the shortage of fossil evidence from the core material. So far, the only dated material available is from the sequence at Ljunghusen 1 where the chitinozoans indicate that the youngest beds along to the lowermost part of the *Cyrtograptus* Shale, i.e. the *M. crenulatus* zone (Sven Laufeld, personal communication 1978). The uppermost Silurian shales in this borehole are strongly weathered, a phenomenon also observed in the cuttings from other boreholes. The deep wells penetrating into Silurian beds show no evidence of any beds of post-*Colonus* age and with lithologies similar to the sediments of the Öved-Ramsåsa Beds. In this context it is worth mentioning that late Silurian beds with faunas and lithologies resembling those of the Öved-Ramsåsa Beds and the upper part of the *Colonus* Shale in Scania have been encountered in two deep wells further to the west, in Denmark, at Nøvling 1, at depths between 3535 and 3762 m (Christensen 1971a, 1973) and Rønde 1, betweeen 4970 and 5300 m (Christensen 1971b, 1973). From the former well several tentaculitid species were reported from various levels. One specimen was figured (Christensen 1971a, Pl. 2: 5) but the illustration does not permit specific determination. It is likely that the late Ludlovian and possibly early Downtonian beds have had a wide distribution before the onset of the post-Silurian erosion.

The Silurian sequence is considerably thicker in Scania than in other areas of Sweden. The total thickness is not known accurately, because of the faulting of the beds and the limited amount of exposure. Regnéll (1960: 26) estimated a total thickness of 1000–1500 m, which is corroborated to a certain extent by the values obtained from the deep wells in SW Scania. It is obvious that tectonic subsidence and a prolific influx of argillaceous material from the Precambrian shield area favoured the relatively fast accumulation of thick sequences of sediments. A climax in sedimentation rate seems to have been reached during the deposition of the *Colonus* Shale, which is estimated to form more than half of the total thickness of the Silurian. In late Ludlovian–early Downtonian time shallow-water conditions prevailed, with carbonate sedimentation and growth of biostromes, a prolific algal flora and a rich marine fauna. The youngest sediments are represented by regressive sandstones of red bed type.

The four main units will be looked at in more detail. The lowermost one, the *Rastrites* Shale, is composed chiefly of black shales interstratified with occasional beds of grey shale especially in the uppermost part. Some very thin beds of dark calcilutites occur in the lower part of the unit. The upper part has a number of metabentonite horizons. The *Rastrites* Shale of Scania is very complete and part is very rich in graptolites. Its thickness has been estimated to vary between 40 and 120 m (Regnéll 1960:26). It and the lowermost graptolite zone of the superimposed *Cyrtograptus* Shale form the Llandoverian sequence.

The *Cyrtograptus* Shale apart from its lowest graptolite zone, together with the *P. ludensis* zone of the *Colonus* Shale, comprise the Wenlockian sequence (Laufeld *et al.* 1975). The predominant lithology is shale, grey to black or, occasionally, brownish to greenish. Lenses and thin beds of grey to yellowish, dense limestone occur frequently. There are local developments of dark mudstones and of thin metabentonite layers, especially in the lowermost part of the Shale (Hede 1958: 79, 319). There is a lateral change in the facies from SE to NW; the limestone inclusions which are common in SE Scania (Moberg 1910: 166; Laufeld *et al.* 1975: 212) are missing in the area north of Lund (Östra Odarslöv). The *Cyrtograptus* Shale of the Östra Odarslöv area is lighter in colour than that in south-eastern Scania (Laufeld *et al.* 1975: 212). The series is generally fossiliferous, with graptolites predominant and abundant. The mixed graptolitic and shelly fauna at Smedstorp which had been tentatively referred to the *Cyrtograptus* Shale (Hede 1915) is now considered, on good evidence, to form the base of the *Colonus* Shale (Laufeld *et al.* 1975). Laufeld *et al.* (1975) also defined properly the contact between the *Cyrtograptus* and *Colonus* Shales. The total thickness of the *Cyrtograptus* Shale is estimated to be about 100 m (Regnéll 1960: 27; Lindström 1971: 435).

The *Colonus* Shale is considered to constitute more than half the total thickness of the Silurian in Scania. Unfortunately a reliable figure cannot yet be given for its thickness because the upper contact with the Öved-Ramsåsa Group has never been recognized, nor have post-*scanicus* zones. Various estimates have been made: 1100 m (Tullberg 1882a: 14, 1883: 223), 600 m (Hede 1958: 68; Regnéll 1960: 30), 700 m (Lindström 1971: 425). The *Colonus* Shale mainly comprises light-grey, greenish, bluish or reddish micaceous shales which are occasionally rather calcareous. Frequent thin beds of grey limestone are intercalated with the shales. The base of the series is composed of olive-grey, calcareous, slightly silty mudstone as observed at Östra Odarslöv (Laufeld *et al.* 1975). According to Laufeld *et al.* (1975) the lithology of this basal unit and its graptolitic and shelly faunas together indicate a shallower marine environment than is indicated by the purely graptolitic faunas (Laufeld *et al.* 1975: 220). Units deposited up to the end of *nassa/dubius* time are characterized by slow and in part rhythmic, deposition of dark muds which have rich organic content and planktic organisms. The overlying sediments mark a lowering of the sea level and in increased rate of sedimentation (Laufeld *et al.* 1975: 220). The basal beds at Östra Odarslöv and Smedstorp have a lower organic content but more benthic organisms than the *Rastrites* and *Cyrtograptus* Shales. The unit has further indications of shallow-water conditions. At some places there occurs an even-grained, brownish to brownish grey siltstone or fine sandstone, occasionally strongly micaceous and calcareous. This lithological unit, the Odarslöv Sandstone (which rather should be called the Odarslöv Siltstone), is very poorly fossiliferous, and its stratigraphical position within the series is still uncertain. Mixed graptolitic and shelly faunas occur at several localities, some of which have thin beds of limestone intercalated with the shale. The localities include Tosterup and Tolånga with the so-called *Pterochaemia* Shale, and Röddinge and Skarhult. The two latter localities are important because they have the earliest tentaculitid faunas so far encountered in Scania. The supposed minute tentaculitid reported at this level at Smedstorp (Hede 1915) turns out to be an indeterminable conical-shaped organism with no affinity to tentaculitoids. The whole of the *Colonus* Shale, apart from its lowermost graptolite zone belongs to the Ludlovian Series.

The youngest Silurian beds in Scania are grouped as the Öved-Ramsåsa Beds. This sequence consists chiefly of marine shallow-water sediments which, in the upper part, are regressive in type. The various members of the Group are exposed in three principal areas, around Klinta, Öved-Bjärsjölagård and Ramsåsa (Fig. 2). The Öved-Ramsåsa Beds were divided by Grönwall (1897) into four lithostratigraphical units termed, in ascending order, numerical divisions 1–4, and this division is still in use (cf. Jeppsson 1974). Eichstädt (1888) had earlier used a six-fold division of the unit. Lithostratigraphical names were also introduced by early students. In 1841, Hisinger introduced the name Öved Sandstone (*Öveds sandsten*) for the red sandstone at Övedskloster (Hisinger 1841). Tullberg (1882a: 13) introduced names for the three units recognized below the Öved Sandstone, in descending order, the Klinta Limestone and Shale (*Klinta kalk och skiffer*), Kärrtorp Sandstones (*Kärrtorp sandstenar*), and Bjärsjölagård Shale and Limestone (*Bjärsjölagård skiffer och kalk*). These units together with the Öved Sandstone were subsequently defined properly by Tullberg (1882b:

25–28). These names have been little used in later papers dealing with the Öved-Ramsåsa Beds, and the names of the two middle units seem to have been dropped entirely (Regnéll 1960, Table III; Jeppsson 1974). Lithostratigraphical names of modern type have been used, e.g., Klinta Formation (Jeppsson 1974), but their definition is vague or non-existent. It is clear that proper lithostratigraphical names defined according to modern stratigraphical principles are needed for the Öved-Ramsåsa Beds. Advantage should be taken of the several cored boreholes and the monographs on important fossil groups which together provide better stratigraphical guidance now than the early students had.

Few biostratigraphical subdivisions have so far been recognized. For palaeocope ostracodes (Martinsson 1967), three faunas were proved and two inferred to be represented in the Öved-Ramsåsa Beds. These faunas were correlated with faunas from Gotland and other European and North-American areas. In a recent paper (Martinsson 1976b) palaeocope faunas from the Öved-Ramsåsa Beds were discussed in relation to late Silurian ostracode faunas of Baltoscandia and especially those associated with the "*Beyrichienkalk* problem". Jeppsson (1974) distinguished seven conodont faunas in the Öved-Ramsåsa Beds and correlated them with international time units and the local topo- and lithostratigraphical units in Scania and Gotland (Jeppsson 1974: 7–12, Fig. 6).

The lowermost member of the Öved-Ramsåsa Group, unit *1 sensu* Grönwall (1897), is composed of grey, bluish or yellowish grey, calcareous shales. These shales are strongly micaceous in the lower part. Lenses of grey or reddish grey limestone occur frequently. At Bjärsjölagård a large limestone lens which has yielded a prolific fauna and flora has been quarried. The early students of the Öved-Ramsåsa Beds distinguished two sub-units, *1a* and *1b* (Grönwall 1897) or three subunits, *1–3* (Eichstädt 1888). The former division was based on work in the Bjärsjölagård area, the latter in the Klinta area. These subdivisions seem to be corroborated to some extent by studies of palaeocope ostracodes (Martinsson 1967) and conodonts (Jeppsson 1974). Likewise the tentaculitids, although the stratigraphical control of most of the samples studied does not permit exact delimitation of the subunits. The lower boundary of subunit *1* with the *Colonus* Shale has not yet been defined because this contact is nowhere exposed nor has been proved in boreholes.

Subunit *2* (Grönwall 1897), is white and yellow sandstones. These sandstones are almost barren of fossils, having only some poorly preserved bivalves and obscure plant (?) remains (Tullberg 1882a: 13, 1882b: 25).

Subunit *3* (Grönwall 1897) consists of bluish grey or reddish grey to red calcareous shales with occasional thin beds of limestone. The grey colour is confined to the basal layers which are nowadays accessible principally in the Skartofta area. Subunit *3* is fairly fossiliferous and is particularly well developed in the Klinta and Ramsåsa areas.

The uppermost part of the Öved-Ramsåsa Beds, subunit *4* (Grönwall 1897), is composed of a red to grey, thick-bedded sandstone, the Öved Sandstone. This sandstone is sometimes cross-bedded and often fairly shaly. A thinner-bedded variety is very rich in mica. In general the sandstones are poorly fossiliferous. In the Ramsåsa area a few limestone bands are interstratified with the sandstones. These limestones exhibit the youngest tentaculitid fauna encountered hitherto in Sweden. The concomitant fauna is very rich and frequently contains abundant fish remains, occasionally in bone-beds.

The total thickness of the Öved-Ramsåsa beds is still uncertain. It has been estimated to vary between 100 and 800 m (Regnéll 1960). A figure of 300–400 m, which is indicated by the sections penetrated in the boreholes drilled by the Geological Survey of Sweden in 1967–1968 and 1971, is probably more correct.

The lowermost subunits, *1–2*, are correlated with the upper Leintwardinian–lower Whitcliffian, while subunits *3–4* are regarded as equivalent to the Downton Castle Sandstone (Martinsson 1967: 376; 1976b, Fig. 3). This correlation has also been corroborated by conodont evidence (Jeppsson 1974: 12).

Localities, samples and tentaculitids

The present study is based on a great amount of material which comprises samples collected by myself, by colleagues, and museum collections. The majority of the material consists of surface samples. Only in a few cases has subsurface material been examined, and this was not systematically collected but rather was obtained as a result of occasional finds of tentaculitids among other fossils searched for in cores. There are, however, one important exception, the borehole Bjärsjölagårdborrningen 1 in Scania which was drilled by the Geological Survey of Sweden in 1966–1967. From that core practically all tentaculitid material has been examined.

I was very fortunate to have had full access to Anders Martinsson's large collections from Gotland and Scania, collected over more than 20 years in the course of his investigations on the palaeocope ostracodes of Sweden. These samples amount in total to 830, of which there are 816 samples from 222 localities on Gotland and 14 samples from three localities in Scania. Among the localities on Gotland, 111 were described in Martinsson (1962: 46–59) and later included together with many additional localities in Laufeld (1974a). Many localities originally sampled by Martinsson after 1962 but not yet described in literature are described here. Martinsson's samples are designated with his code MS and a current laboratory number, e.g., MS 389.

The bulk of Anders Martinsson's samples are from marl. I wished to obtain a denser sampling pattern in order to determine tentaculitid distribution in various lithologies and to improve the stratigraphical control. From the locality map, Fig. 3, it can be seen that the sampling stations have a fairly comprehensive areal distribution over the entire island, although a few areas are

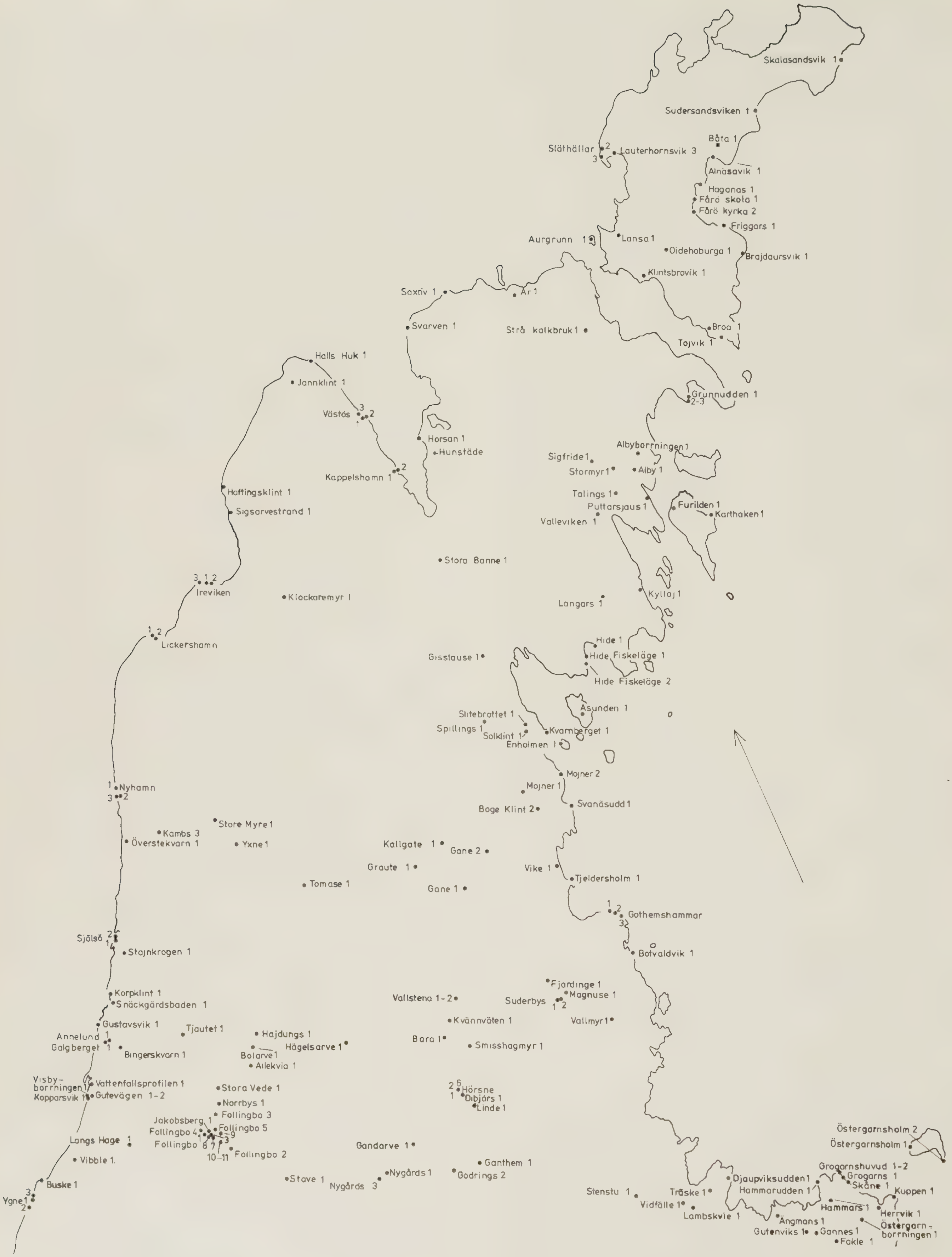
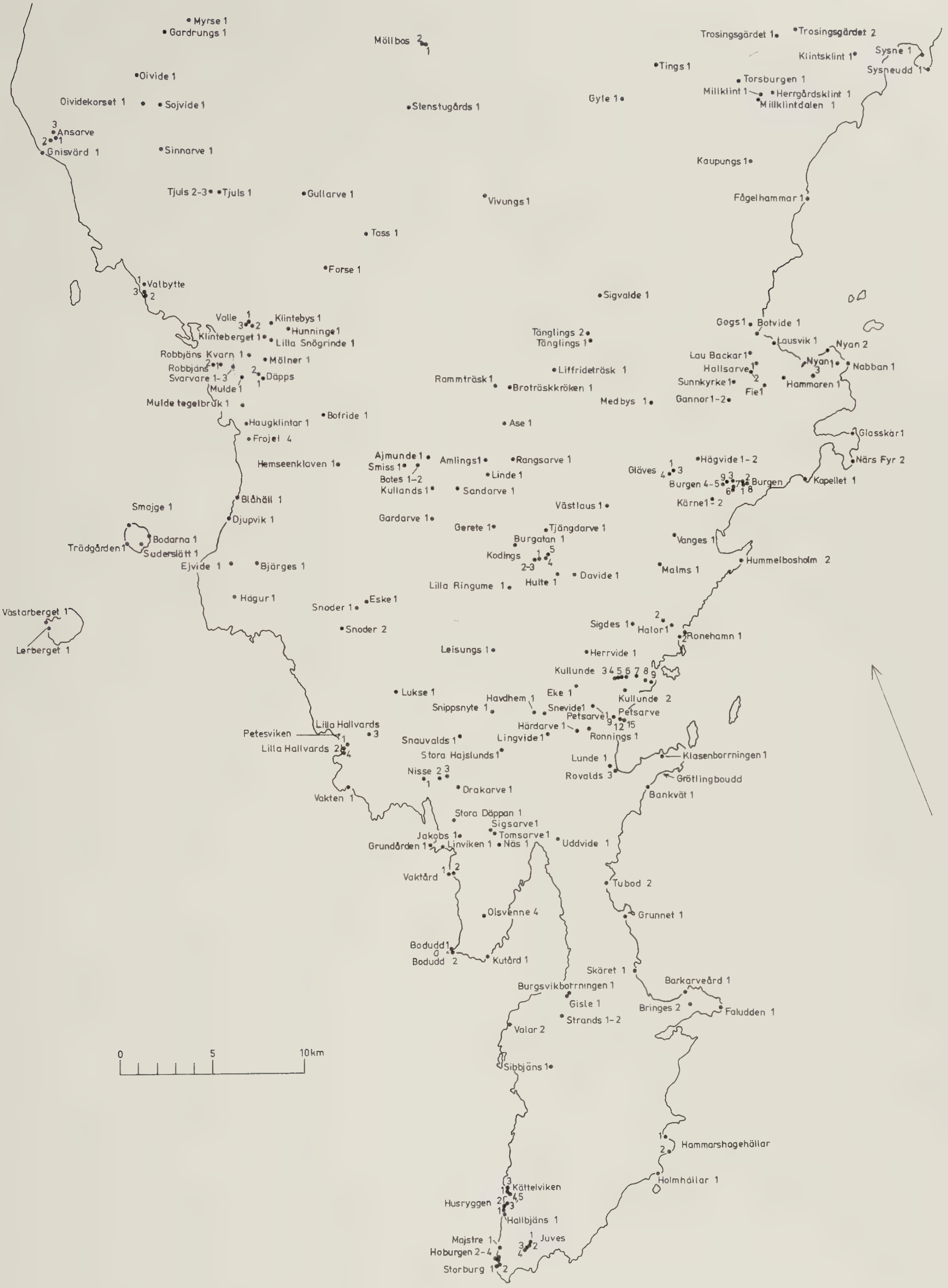

Skalasandsvik 1
Sudersandsviken 1
Båta 1
Släthällar 2 3
Lauterhornsvik 3
Alnäsavik 1
Haganas 1
Fårö skola 1
Fårö kyrka 2
Friggars 1
Aurgrunn 1
Lansa 1
Oidehoburga 1
Brajdaursvik 1
Klintsbrovik 1
Saxriv 1
Ar 1
Svarven 1
Strå kalkbruk 1
Broa 1
Tojvik 1
Halls Huk 1
Jannklint 1
Västös 3 2 1
Grunnudden 1 2-3
Horsan 1
Hunstäde
Kappelshamn 1 2
Albyborrningen 1
Sigfride 1
Stormyr 1
Alby 1
Haftingsklint 1
Sigsarvestrand 1
Talings 1
Puttarsjaus 1
Valleviken 1
Furilden 1
Karthaken 1
Stora Banne 1
3 1 2 Ireviken
Klockaremyr 1
Langars 1
Kyllaj 1
1 2 Lickershamn
Hide 1
Gisslause 1
Hide Fiskeläge 1
Hide Fiskeläge 2
Asunden 1
Slitebrottet 1
Spillings 1
Solklint 1
Kvarnberget 1
Enholmen 1
Mojner 2
1 Nyhamn 3 2
Mojner 1
Svanäsudd 1
Boge Klint 2
Store Myre 1
Kambs 3
Överstekvarn 1
Yxne 1
Kallgate 1
Gane 2
Graute 1
Vike 1
Tjeldersholm 1
Tomase 1
Gane 1
1 2 Gothemshammar 3
Själsö 2 1
Stajnkrogen 1
Botvaldvik 1
Fjardinge 1
Korpklint 1
Snäckgärdsbaden 1
Vallstena 1-2
Magnuse 1
Suderbys 1 2
Gustavsvik 1
Kvännväten 1
Vallmyr 1
Tjautet 1
Annelund 1
Galgberget 1
Hajdungs 1
Bara 1
Hägelsarve 1
Bingerskvarn 1
Bolarve 1
Smisshagmyr 1
Allekvia 1
Visby-borrningen 1
Vattenfallsprofilen 1
Kopparsvik 1
Gutevägen 1-2
Stora Vede 1
2 6 Hörsne 1
Dibjärs 1
Linde 1
Norrbys 1
Follingbo 3
Jakobsberg 1
Follingbo 4
Follingbo 5
-9
1 3
Follingbo 8 7
10-11
Follingbo 2
Langs Hage 1
Gandarve 1
Östergarnsholm 2
Östergarnsholm 1
Vibble 1.
Ganthem 1
Grogarnshuvud 1-2
Nygårds 1
Godrings 2
Djaupviksudden 1
Grogarns 1
Buske 1
Stave 1
Skåne 1
Nygårds 3
Stenstu 1
Träske 1
Hammarudden 1
Kuppen 1
Ygne 3 1 2
Vidfälle 1
Hammars 1
Herrvik 1
Lambskvie 1
Ängmans 1
Östergarn-borrningen 1
Gutenviks 1
Gannes 1
Fakle 1

Fig. 3. Sketch map of Gotland showing the sample localities with their code names. Base map: topographical map sheets 1: 100 000. For descriptions of the localities, see Appendix (herein) and Laufeld 1974a.


Myrse 1
Gardrungs 1
Möllbos 2 1
Trosingsgärdet 1
Trosingsgärdet 2
Sysne 1
Klintsklint 1
Sysneudd 1
Tings 1
Torsburgen 1
Millklint 1
Herrgårdsklint 1
Millklintdalen 1
Gyle 1
Oivide 1
Oividekorset 1
Sojvide 1
Stenstugårds 1
3 Ansarve 2 1
Gnisvärd 1
Sinnarve 1
Kaupungs 1
Tjuls 2-3
Tjuls 1
Gullarve 1
Vivungs 1
Fågelhammar 1
Tass 1
Forse 1
1 Valbytte 3 2
Sigvalde 1
Valle 1 3 2
Klintebys 1
Hunninge 1
Klinteberget 1
Lilla Snögrinde 1
Tänglings 2
Tänglings 1
Gogs 1
Botvide 1
Lausvik 1
Nyan 2
Robbjäns Kvarn 1
Mölner 1
Robbjäns 2 1
Svarvare 1-3
Däpps 2 1
Mulde 1
Mulde tegelbruk 1
Liffrideträsk 1
Rammträsk 1
Broträskkröken 1
Lau Backar 1
Hallsarve 1 2
Sunnkyrke 1
Fie 1
Nyan 1 3
Nabban 1
Hammaren 1
Gannor 1-2
Medbys 1
Bofride 1
Haugklintar 1
Frojel 4
Ase 1
Glasskär 1
Ajmunde 1
Smiss 1
Amlings 1
Rangsarve 1
Hemseenklaven 1
Linde 1
Botes 1-2
Kullands 1
Sandarve 1
Gläves 1 4 3
Hägvide 1-2
Burgen 4-5 9 3 7 2 6 1 8
Burgen
När Fyr 2
Kapellet 1
Blåhäll 1
Smojge 1
Djupvik 1
Västlaus 1
Kärne 1 2
Gardarve 1
Gerete 1
Tjängdarve 1
Burgatan 1
Bodarna 1
Trädgården 1
Suderslätt 1
Vanges 1
Kodings 1 5 2-3 4
Hummelbosholm 2
Ejvide 1
Bjärges 1
Davide 1
Malms 1
Hulte 1
Lilla Ringume 1
Hägur 1
Eske 1
Snoder 1
Västarberget 1
Lerberget 1
Snoder 2
Sigdes 1
Halor 1 2
Ronehamn 1 2
Leisungs 1
Herrvide 1
Kullunde 3 4 5 6 7 8 9
Lukse 1
Havdhem 1
Eke 1
Kullunde 2
Snippsnyte 1
Snevide 1
Petsarve 1
Petsarve 9 12 15
Lilla Hallvards 1 3
Petesviken
Härdarve 1
Ronnings 1
Lilla Hallvards 2 4
Snauvalds 1
Lingvide 1
Stora Hajslunds 1
Lunde 1
Klasenborrningen 1
Nisse 2 3 1
Rovalds 3
Grötlingboudd
Drakarve 1
Vakten 1
Bankvät 1
Stora Däppan 1
Sigsarve 1
Jakobs 1
Tomsarve 1
Grundården 1
Linviken 1
Näs 1
Uddvide 1
Vaktård 1 2
Tubod 2
Olsvenne 4
Grunnet 1
Bodudd 1 0
Bodudd 2
Kutård 1
Skäret 1
Burgsvikborrningen 1
Barkarveård 1
Gisle 1
Bringes 2
Faludden 1
Strands 1-2
Valar 2
0 5 10km
Sibbjäns 1
1 2 Hammarshagehällar
Holmhällar 1
3 1 Kättelviken
Husryggen 2 4,5 3 1
Hallbjäns 1
Majstre 1
Juves 1 3 2 4
Hoburgen 2-4
Storburg 1 2

more sparsely sampled, e.g. in the forested areas with Klinteberg Limestone and in the limestone units of the Tofta and Högklint Beds. However, it became apparent rather early that these limestones had a very low tentaculitid yield, and thus it would have been too time-consuming to sample them properly. However, it is clear that the shortage of samples from these areas has not reduced knowledge of the vertical distribution of the various tentaculitid species.

In Scania the outcrops with Late Silurian rocks are much fewer than were available earlier to, for example, Eichstädt (1888), Grönwall (1897), and Moberg & Grönwall (1909). Localities have now become overgrown or been destroyed, sometimes by dumping, especially in the Ramsåsa area. Much material collected by the early workers is available in the museum collections of the Palaeontological Department in Lund, and it has all been examined for the present study. Unfortunately much of it suffers from somewhat imprecise notes on the exact geographical position, and the stratigraphical level is uncertain. Consequently many samples had to be disregarded although in several cases they exhibited well preserved tentaculitids. There are some hand specimens which are obviously incorrectly labelled, or placed in wrong sample boxes, etc., so the material has to be used with caution. Fortunately, I have been able to improve the state of these collections considerably, by cross-reference to the well defined material collected by Dr. Lennart Jeppsson for his conodont studies.

I have also had access to many samples collected by my colleagues working on Gotland. A number of these samples derive from new localities which will be described herein. It is an important strategy in Project Ecostratigraphy to gather as much information as possible from each sampling spot in order to simplify synthesis of results obtained from studies of individual fossil groups, lithologies, etc. Therefore we attempt to use each other's samples as far as possible. Certainly the nature of each sample will determine which fossil groups can be investigated. In general, the marly samples used for this study have also been picked for the palaeocope ostracodes, small brachiopods, machaeridians, small crinoids, conodonts and, in some instances, primitive vertebrates.

In total 1226 samples from 395 localities on Gotland and 433 samples from 32 localities in Scania have been examined. It is evident from these figures that the investigation included several tens of thousands of tentaculitids. Not all localities or samples yielded tentaculitids, but these localities and samples are still included in the locality list because they are relevant to the distributional pattern of the tentaculitids. The lack of tentaculitids at a locality certainly does not mean that they are totally absent there but it gives some limit on their relative abundance.

The description of localities conforms with the recommendations given in Laufeld (1974a). One major change, however, is that the Swedish National Grid System is used for the grid references. Unfortunately this system has now replaced the Universal Transverse Mercator (UTM) grid system on all new editions of the topographical map sheets of Gotland. The UTM figures are still printed in the margin of the sheets, and could certainly be used, but with less precision and more difficulty. It is practical to convert to the new grid system for locality descriptions because the older editions of the topographical maps will successively run out of print. It is convenient to take this step now, before the number of localities increases too much. In the transition period both grid reference systems should be used in descriptions, preferably with the UTM coordinates in parentheses. A computer conversion of the UTM grid coordinates into the National Grid coordinates for all localities previously described (Laufeld 1974a) is now available and may be obtained from me upon request. Localities from Scania are described in the same manner. Most were briefly described by Jeppsson (1974: 49–51). The locality description also include boreholes, which are distinguished by the suffix *-borrningen* (Swedish for borehole).

Unfortunately, some of the museum material examined derives from geographically and stratigraphically imprecise locations. However, some such material is sufficiently important for inclusion, e.g. samples labelled Hunstäde (Högklint Beds) and Grötlingboudd (Hamra Beds). Other fossils, such as palaeocope ostracodes, enabled the stratigraphical position to be determined safely. For these localities, brief descriptions are given and they are referred to the general areas. The locality map, Fig. 3, shows these localities by arrows.

The new localities described and those already defined (Laufeld 1974a) are listed alphabetically. The stratigraphical position, and a brief description of the main lithologies at the locality are given, followed by the sample number and the names of the tentaculitids found. Many members of the team working on Gotland and in Scania use individual sample numbers to identify their samples. As Laufeld (1974b) pointed out, several workers use the same code, which can lead to confusion when the samples are used simultaneously. I have added a suffix of two letters to the sample number in order to separate the samples. The same system is used by Laufeld & Jeppsson (1976). The sample codes are as follows: *Museum material:* SMNH No. X + number (Swedish Museum of Natural History, Stockholm); LR or LO + number (Palaeontological Department, Lund: PDL); SGU Te + number (Geological Survey of Sweden; this is my own code because no official museum code is so far established). *Private collections:* Own Gotland material, G + year + number + KL, e.g. G75-4 KL. The same system is used for other private Gotland collections with the suffixes CB (Christina Bengtson), SB (Stefan Bengtson), MB (M. G. Bassett), LJ (Lennart Jeppsson). Anders Martinsson's processed marl samples all have the code MS + number corresponding to field numbers like 58 G 16 (Gotland, 1958) or 61 G 12 (Scania, 1961).

For the Scanian material, a more heterogeneous labelling pattern is in use. There, the first letters denote the different localities, e.g., Sk for Skarhult, Bj for Bjärsjölagård, etc. Samples from cores are referred to their position below ground level.

The sample localities and the description of new localities are listed in Appendix. Each sample locality on

Gotland and in Scania is represented by a black dot together with the name on Figs. 2 and 3.

Depositories. – All figured and measured material designated by codes including the prefix SMNH is deposited at the Swedish Museum of Natural History in Stockholm. Material deposited at the Geological Survey of Sweden in Stockholm (from 1979 in Uppsala) bears the prefix SGU, and at the Palaeontological Department of the Geological Institute in Lund the prefix LR or LO. The material of *Podolites paeninsulicola* n. sp. is deposited at the Museum für Naturkunde in Berlin.

Methods

Very little has been written on the methodology for tentaculitoid studies. Ljashenko (1953: 371; 1954: 31) gave some notes on the application of thin sectioning and photography of the material. Bouček (1964: 18) used washed material and also silicified material obtained through dissolving limestones. Lardeux (1969: 6–7) has submitted the most comprehensive report so far on methods for the study of tentaculitoids, in which he concluded that these methods do not differ in general from those used commonly in invertebrate paleontology. Hajłasz (1974: 457) used handpreparation by needles, then completely etched poorly preserved tentaculitid specimens in a non-carbonatic matrix and produced latex moulds. Yoder & Ertdmann (1975: 379–380) disintegrated their samples by repeatedly freezing and thawing and cleaned the conchs in an ultrasonic vibrator tank.

The methodology of collecting and processing marly material has been described in detail by Martinsson (1962: 38–42) and Laufeld (1974b: 4–7). Most of these methods have been found applicable in this study and they will be discussed below.

Collecting. – Preliminary examination of the marl samples collected by Anders Martinsson showed that loose marlstones and unconsolidated marls had high potential for tentaculitid studies. Thus, the main part of my own sampling has been in the marly regions of Gotland, in marly intercalations between limestone beds and in marl pockets in reef limestones. This results in approximately 90% of the total number of samples originating from marly beds. Certainly with this strong biofacial specialization there is a risk of missing important faunal components which dwell in other environments. The problems related to this restricted sampling have been discussed by Martinsson (1962: 12, 38) who clearly demonstrated that, in the case of palaeocope ostracodes, the risk was minimal. This is valid also for tentaculitids. Control sampling in various lithologies at a number of localities all over Gotland as well as in Scania shows that there was little risk of missing tentaculitid faunas. In some areas of Gotland and Scania no marl samples have been accessible and sampling has been correspondingly limited. This is especially the case in the limestone belts of the Högklint, Klinteberg and Sundre Beds, where very few localities have yielded sufficient or well enough preserved tentaculitids to justify continued sampling. This is reflected in the density of sample localities (Fig. 3). The uneven distribution of localities is not limited to this investigation (cf. Martinsson 1962, Fig. 4; Laufeld 1974b, Fig. 2), and its effect on the stratigraphical distribution of the tentaculitids is small (as was also shown in the two papers cited).

My intentions have been to obtain abundant and well-preserved material which could show the variation in morphological characters within each taxon, and to get a reliable picture of the stratigraphical distribution and occurrence in various environments. The marl samples have fulfilled these aims. The only drawback with these samples is that the tentaculitid conchs tend to be fragmented, especially in loose marls. Probably fragmentation occurred at an early stage of the sedimentation, but no doubt the processing of the samples also contributed. In order to obtain complete specimens, localities with more consolidated marlstones and limestones were visited, and not without a certain success. However, searching for slabs with well preserved tentaculitids is time-consuming. As may be seen in Hede's left collection of tentaculitids, he confined his search for tentaculitids to well consolidated marlstones and argillaceous limestones. Thus, his material is much less fragmented and many conchs are beautifully preserved. Time has not permitted to use this material fully, however.

A standard paper bag containing ca. 2000 cm^3 was filled with marl, or in many localities even more depending on the accessibility and state of weathering of the material. Thus, the material from each locality amounts to 4–5 kilograms on average. Martinsson's (1962: 39) samples weighed 2–200 kilograms, averaging about 10 kilograms. The quantity of tentaculitid material obtained from his samples is biased by the size of the sample. Hence, no quantitative data on abundance other than 'rare', 'common' and 'abundant' are given in the descriptive part.

The usual vertical thickness sampled in marls was 5–10 cm but from many of the beds intercalated between limestones was less. Marly material was commonly sampled after some years' exposure, when it had weathered.

The material collected in 1972–1973 relates less to reference levels at the various localities as described by Laufeld (1974b). In general, vertical and horizontal extensions of outcrops on Gotland are small except in the coastal cliffs. The risk of combining different units within a sample is therefore negligible. When the precision of sampling was doubtful, as in localities with an exposed boundary between major stratigraphical units, these localities were revisited and resampled in 1974–1975. However, my own sampling is less exact than the sampling of chitinozoans to centimetre precision performed by Laufeld (1974b). It is preferable for the continued investigations in the Silurian of Gotland and Scania to follow Laufeld's (1974b: 4) recommendation and refer all samples to natural or artificial markers. Then, replication of sampling localities and levels may be achieved by several workers.

Treatment of samples. – The marl samples were treated in hot water. This method normally produces full disintegration of the material, but in more consolidated marlstones another method was necessary. The sample is heated to 100°C, then soaked immediately with a convenient hydrocarbon, e.g., varnolene. After 10–15 minutes, the excess fluid is removed and cold water added to the sample. After a few minutes the rock disintegrates completely. and then it is washed and sieved with screens of 2, 1, 0.5, 0.25 and 0.125 mm mesh. To reduce the risk of breaking the tentaculitids during screening, the screens are held partly under water in a wide basin. Only gentle movement of the screen is enough to pass the material through it.

For some limestone samples, e.g. from Ramsåsa 8, etching was used to free the tentaculitids, because they were largely phosphatized. Silicification of the fossils in the samples is uncommon so etching is mostly unnecessary.

The extraction of the tentaculitids followed the same routine as was described by Martinsson (1956: 4; 1962: 39–49).

For individual preparation, needles and vibro-tools were used. These enabled the surface of the tentaculitid conch in most cases to be removed from marly matrix. Marl can be difficult to detach though, and in several specimens it was impossible to remove it completely, and especially from the interspaces. The preparation methods of Martinsson (1962: 40; 1965a: 247–251) were attempted, but not with full success. Ultrasonic cleaning was not successful either because the conchs frequently tended to crack. One successful method was to place the conch into very dilute acetic acid (1 %) and clean it with small brushes which had the hairs cut to 1–2 mm length. If done quickly, say 4–6 minutes, very little corrosion of the conch occurred, yet the interspaces could be freed completely of matrix. Fine ornament such as lirae is not much affected. The method may appear drastic, but it was found to be effective and not harmful. It should certainly not be used for material to be examined with SEM. In such cases, only cleaning with hot water and then soft brushes should be applied.

Important to study of tentaculitids is sectioning the conch. Initially, longitudinal thin sections were made. This is time-consuming when, without access to machines for thin-sectioning, all grinding must be done manually. Thus, such sections were made only for a limited number of conchs of each species. Instead, grinding and polishing was only done on the sagittal plane of the conch. This is enough to reveal the internal structures. Because much of the material sectioned was investigated by scanning electron microscopy (SEM), this simplified method was adequate for examining the microstructure of the wall and septa.

A serious problem has been to obtain exact sagittal sections. When conchs in matrix were sectioned, epoxy resin was first poured around them in order to obtain a wide, flat surface parallel to the sagittal plane of the tentaculitid. Loose specimens were placed on a cover glass attached with a thermoplastic to an objective glass. A glass fragment was placed below the proximal end of the conch to obtain proper orientation. Then, epoxy resin was poured over the specimen, covering it entirely. In order to facilitate orientation of the conch during grinding, small glass fragments were cemented to each corner of the cover glass. After complete hardening of the epoxy resin, hand-grinding using successively finer grinding powders could be done. After polishing, the cover glass and sectioned conch could be easily removed from the objective glass by gentle heating and then mounted either on a stub for SEM examination or on a petrographic glass for thin-sectioning.

Photography. – For photographing the material, a Leitz Aristophot equipped with 42 mm or 63 mm Leitz summar objectives mounted with a Leica camera for 24 × 36 mm negatives was used. Because medium-sized and large tentaculitid species are close to the upper size capacity of this equipment, a Leitz Reprovit 2a camera for 24 × 36 mm negatives with a Focotar-2 1: 45/50 mm objective and extension rings was used. The films were Kodak Panatomic X, 16° DIN for 24 × 36 mm negatives. In the Aristophot camera, the diaphragm was invariably F: 12–16, in the Leitz F: 8. The light sources was a fluorescent illuminator, the light falling from the upper right corner. To eliminate heavy shadows from the rings, white paper reflectors were placed 1–2 cm from the conch. The bellows of the cameras were arranged for negative scales of × 5 or 10. For the prints, Agfa Rapidoprint papers of various hardnesses were used.

Free conchs were mounted for photography onto a small piece of black cardboard. The specimen was glued with cellulose acetate or saliva. After proper orientation, the specimen was coated with a very thin layer of sublimated ammonium chloride as described by Martinsson (1962: 42). Slabs with specimens in matrix were cut in small pieces before photography, to facilitate orientation of the specimen below the objective of the camera. To improve contrast, brown or black indian ink was painted around the specimen. With each film and set-up of the equipment, an object micrometer scale was photographed to give exact magnification when printing.

Scanning electron microscopy. – Much scanning electron microscopy (SEM) was carried out, using JEOL JSM-U3 equipment. Polished sections were mounted on specimen stubs. Many free conchs were mounted directly onto stubs, covered with epoxy resin and, after hardening, ground and polished as described previously. The polished specimens were etched in a 2 % solution of EDTA for 4–6 minutes, the time depending on the character of the conchs. The etched specimens were coated with gold in a sputter, SEM Coating Unit E 500, manufactured by Polaron Equipment Ltd., England. The best coating was obtained at a current of 20 mA for 5–6 minutes.

Photographs were taken at a scanning speed of 50 seconds per frame. The film used was a panachromatic roll film, Ilford FP-4, 22° DIN, with a negative of 60 × 60 mm.

The magnification was read directly from a display on the SEM unit. Knowing the screen size of the JSM-U3

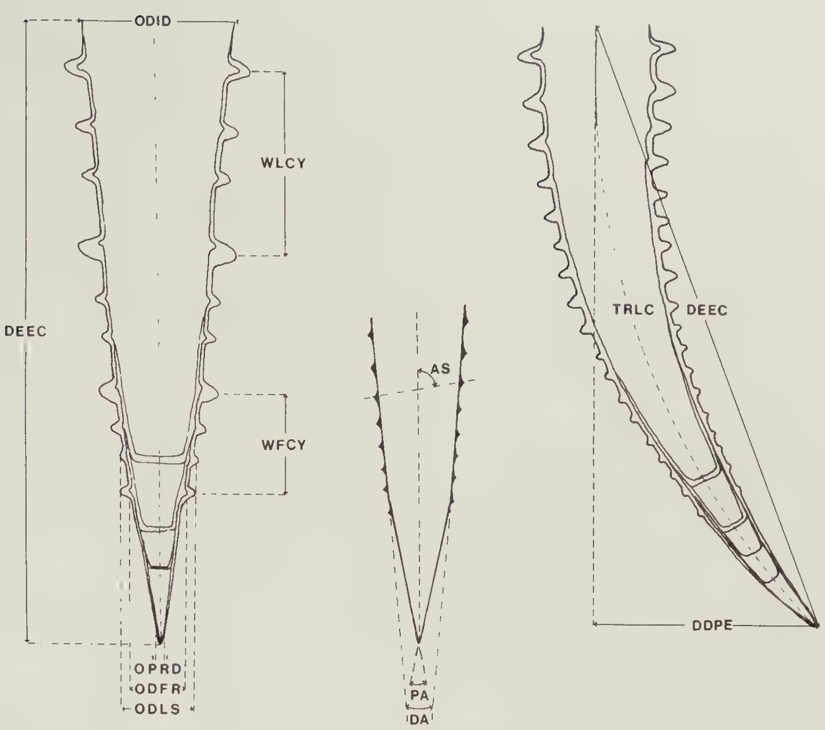


Fig. 4. Biometric measurements for the tentaculitid conch. Abbreviations explained in Table 1.

unit, i.e. 10 × 10 cm, the final magnification of the prints could be easily calculated.

Measurements. – The previous literature describes many different ways of measuring the tentaculitoid conch. Very few authors state exactly how the measurements were obtained. To take just one example, the diameters of the two ends of the conch are generally measured but it is not clear whether the outer diameter has been taken at an interspace or over a ring. These values can differ considerably, occasionally by as much as 40% (e.g. in *Odessites inflatus*). Length measurements are usually less imprecise, but in curved species it is seldom clear whether the curved or linear distance between the two ends has been determined. It is rarely stated whether the length given is for an intact or a fragmented conch.

Additional measurements normally given in descriptions are proximal growth angle, total number of rings, ring density either per mm or for the conch diameter at the point measured. Data are normally tabulated or displayed diagramaticaly, e.g. Bouček (1964: 87), Alberti (1970c: 392), Yoder & Erdtmann (1975: 383–384). The latter authors defined clearly the parameters measured (1975, Fig. 3), and introduced abbreviations for biometric characters. I have adopted this principle, although with modified codes, Fig. 4.

It is important to decide which characters should be measured and how these measurements should be used. Characters significant for description of morphology and development of the conch should be determined. Such characters vary among species because of differences in morphology, especially in the development of the rings but also in the shape of the conch and the septal arrangement. It may be difficult or impossible to compare species for all characters. However, some basic parameters can be determined easily in all species, i.e. length, diameter of the conch at the two ends, proximal growth angle and ring density in different parts of the conch. In addition, measurements such as density of lirae, height and width of rings, length of interspaces, length of living chamber, thickness of conch wall, etc., may generally be easily obtained and should be measured if they are significant for the species. Some basic measurements are tabulated and statistical values such as means and ratios are mentioned in each description. Multivariate analysis has not been attempted. Firstly, there has been no need for comprehensive biometric analysis in order to distinguish taxa. Fortunately, the tentaculitid faunas of Gotland and Scania have well-defined morphological characters which mostly allow simple discrimination of species. Secondly, the number of specimens fully preserved is very low for most species, so that there are too few conchs for values to be statistically valid. To obtain reasonable measurements of internal characters, many more specimens need be sectioned and this is too time-consuming without equipment for sectioning.

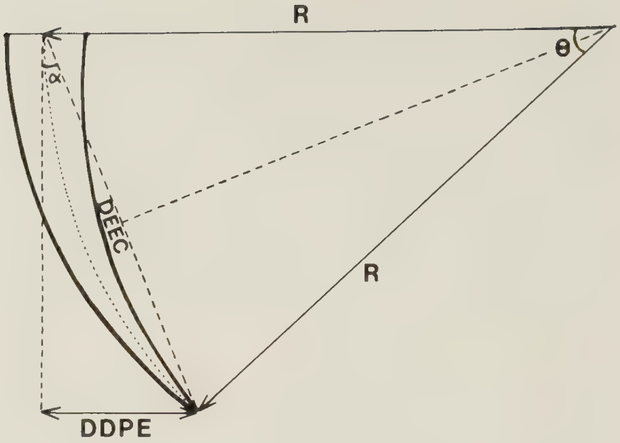
Table 1. Codes used in the tables accompanying the descriptions of the species.

DA	Distal growth angle
DEEC	Distance between ends of conch
DDPE	Distance of deflection of the proximal end from a sagittal plane through the living chamber
NRLC	Number of rings in the last cycle
ODFR	Outer diameter of conch at the first primary ring
ODID	Outer distal diameter
ODLS	Outer diameter of conch at the last septum
OPRD	Outer proximal diameter
PA	Proximal growth angle
TNCY	Total number of cycles
TNRI	Total number of rings
TRLC	True length of conch
WFCY	Width of first cycle
WLCY	Width of last cycle

When material like that used for this study is measured, there are several inaccuracies in the data obtained. Complete, fully preserved specimens are uncommon. Mostly, both external and internal characters are excellently preserved, but the majority of conchs are fragmented into pieces of various lengths. Normally the apical end with the initial chamber is missing and the distal end often lacks the functional aperture. This preservation affects the measurements taken. Here, the length (DEEC) will be that of the piece preserved, the two extreme diameters (OPRD, ODID) will be those measured at the points where the conch has broken. As there is normally no fixed point from which length measurements can be taken, it is difficult to express growth changes numerically in relation to length. A special problem in determining the total length occurs in the strongly curved genus *Gotlandellites.* Direct measurement of the curvature is almost impossible to obtain using a binocular microscope with an ocular micrometer attached. Fortunately, the shape of the curvature of the median line of the conch is very close to that of an arc of a circle. Thus, the straight line between the end points of the median line can be regarded as a chord of a circle having the same radius as the conch. If this "chord" (DEEC) and the deflection of the proximal end from the sagittal plane through the aperture (DDPE) are determined, the length of the curvature, i.e. the true length of the conch (TRLC) may be calculated according to the formula $\mathrm{TRLC} = \frac{\theta}{180°} \cdot \pi \cdot \frac{(\mathrm{DEEC})^2}{2\,(\mathrm{DDPE})}$. This can be easily derived trigonometrically from the formulae for the length of arc of a circle, $L = \frac{\theta}{180°} \cdot \pi \cdot R$, where the median angle is θ and radius R. The derivation of these two values is shown in Fig. 5. For partly curved conchs, the deflection of the proximal end (DDPE) is expressed.

In the table of measurements accompanying each description I use coded biometrical characters (as done by Yoder & Erdtman 1975), mainly for brevity. The characters measured and their codes are summarized in Table 1, and some are shown in Fig. 4. I mostly use different codes than Yoder & Erdtmann (1975) because I prefer to apply neutral terms for the end diameters and length of the conch. There were very few cases when apical ends and aperturaes could be measured.

The accuracy for all linear measurements is to 0.02 mm and for the angular determinations 0.5°.



$$\sin\alpha = \frac{\mathrm{DDPE}}{\mathrm{DEEC}} \qquad (1)$$

$$\alpha = \frac{\theta}{2} \qquad (2)$$

$$\sin\frac{\theta}{2} = \frac{\frac{\mathrm{DEEC}}{2}}{R} \qquad (3)$$

$$\text{(1) and (2) give } \sin\frac{\theta}{2} = \frac{\mathrm{DDPE}}{\mathrm{DEEC}} \qquad (4)$$

$$\text{(3) and (4) give } R = \frac{(\mathrm{DEEC})^2}{2(\mathrm{DDPE})} \qquad (5)$$

Fig. 5. Figure illustrating the derivation of R and θ for calculation of the true length (TLOC) of curved conchs of *Gotlandellites.*

State of preservation and occurrence in the sediment

The tentaculitid material studied is generally very well preserved. Most of the specimens collected are undeformed, and so display their original shape, growth angle, surface ornamentation and internal structures. Such preservation is found in all lithologies sampled, but particularly well preserved specimens come from marls and marlstones of both Gotland and Scania. However, there is a high proportion of broken conchs, and unfractured specimens are extremely rare. In other lithologies, at least one part of the conch is always missing, in most cases the initial chamber. No statistical measurement has been carried out, but it seems that most adult tentaculitid conchs are broken into three or four pieces. In the juvenile part, fragmentation occurs shortly after the initial chamber, i.e. at a conch diameter of 0.10–0.15 mm in most species. This is a point where the conch wall is very thin without any septa strengthening the wall internally. In the adult part fragmentation may occur at several points, but is particularly likely more distally in the conch, especially in walls where little or no secondary shell material has been secreted.

The degree of compression of the tentaculitid conchs is generally low. Thus,, their cross-section is commonly circular. If the conch is compressed, deformation is confined to the adult part, giving it an oval cross-section. Completely flattened conchs are rare, at least in the marls, and longitudinal cracks in the conch are seldom found. Certainly this lack of deformation cannot be interpreted as due to lack of compaction of the seciments. On the contrary, evidence of compaction, such as compression of stylolites and other fossils, is frequently found both on Gotland and in Scania. It seems likely that the comparatively low degree of compression of the tentaculitids is because of rapid filling of the living chamber by sediment, which reduces the differential pressure on the conch during compaction. Most sectioned specimens exhibit living chambers filled with the same type of sediment as embeds the conch. Some conchs show a living chamber filled with clear calcite and/or accumulations of pyrite. For these one may assume rapid embedding of the conch before the decay of the soft parts and a subsequent void filling of calcite in living chamber. In such conchs the portion immediately by the aperture is generally filled by embedding sediment (Fig. 44E).

The camerae of undamaged juvenile parts are mostly filled with calcite, either clear of milky. Occasionally some aggregates of pyrite occur as well. All conchs filled with sediment have been fractured at an early stage of the embedding, and this has permitted sediment to enter the camerae. Blind's (1969: 136) statement that sediment in the camerae was the result of their filling while the animal was alive seems very unlikely.

The tentaculitids are with few exceptions found preserved with their original shell substance, i.e. calcite. Thus the microstructures are always found preserved in detail and the texture of the shell is unaltered. There is no possibility that the conch was constructed of aragonite crystals as Blind (1969: 116) assumed. In the Burgsvik Sandstone, and also in arenaceous levels within the Öved-Ramsåsa Beds in Scania, quartz grains are often pressed into the calcitic laminae of the conch, giving a pitted surface. Such conchs can be hard to clean properly without damage. In limestones, calcite crystals are frequently growing into the conch, and can cause severe problems in the preparation of the conch. No dolomitization or silicification of the original shell substance has been observed. However, silicified tentaculitids undoubtedly occur, as has been proved in silicified limestone beds below some metabentonites on Gotland (Laufeld & Jeppsson 1976: 33, 43). In the uppermost part of the Öved-Ramsåsa Beds of Scania, some levels have yielded tentaculitids which show evidence of phosphatization. The sediment filling the living chambers may be entirely phosphatized, and that portions of the conch may also be phosphatized is seen in samples which have been treated in weak acids. However, such replacement of the original substance is very rare. It seems that phosphatization is selective and mainly confined to the internal cavity of the conch. Phosphatic internal moulds of the living chamber were mentioned briefly and illustrated by Eisenack (1966: 93–94, Pl. 20: 7). His material derives from the *Beyrichienkalk,* i.e. much higher than the level with phosphatization in Scania. His material also shows selective phosphatization clearly.

Replacement by other minerals, such as pyrite or limonite, has only been observed in a few cases in the Öved-Ramsåsa Beds.

The tentaculitids either occur scattered in the sediment or are in accumulations showing preferred orientation. The latter mode is not met with frequently in the samples studied, and oriented conchs have only been observed so far at some levels in Scania, However, oriented tentaculitids have recently been reported also on Gotland at one locality, i.e. Haganäs 1 in the Slite Beds (C. Bergman, personal communication, 1977).

The vast majority of the tentaculitids are found more or less parallel to the sediment surface. There are, however, cases where the conchs occur oblique or almost perpendicular to this surface. In some it is obvious that the orientation is controlled by the presence on the sea bottom of fragments of other fossils which formed relief into depressions of which the conchs have been trapped. This is particularly well seen in the bryozoan-rich sediments at Gothemshammar, Gotland, where the tentaculitids are frequently found between bryozoan zooecia and standing more or less vertically, either proximal or distal end downwards.

The orientation of the conchs in the sediment is very important to reconstruction of the mode of life of tentaculitids. So far, only one occurrence of conchs standing vertically with the apices downwards is known from the literature (Driscoll 1968). Blind (1969, 1970) has suggested a mode of life standing vertically, and I am also inclined to favour such an orientation in the sediment although I cannot present any direct evidence from examination of the samples. There are, however, some other observations which can support the hypothesis; these will be discussed in a later chapter (p. 48).

The material studied shows no signs of sorting. Thus, all sizes of tentaculitid fragments occur together in the same sample. Post-mortem transport seems to have been negligible and wear of the conchs is very slight or non-existent. Wearing removes the outermost laminae of the rings, as is seen in some sectioned specimens.

In a few specimens a peculiar longitudinal wear confined to the juvenile part has been observed. This wear appears as an encircling set of wide, shallow furrows.

Quite frequently conchs are found inserted into each other to give biological cone-in-cone structures. Smaller conchs occur either proximal or distal end first in the living chamber of a larger conch. Even three or four conchs may be stacked thus. The orientation of the inner conch varies considerably, and may be either parallel or oblique to the long axis of the larger conch. The smaller conch commonly occurs close to one side of the wall of the larger conch. In the cases with "cone-in-cone" structures, there is embedding sediment in the living chamber of all conchs (Fig. 30D).

Morphology of the tentaculitid conch and its terminology

Terminological principles

It is obvious from the literature on tentaculitoids that the morphological terminology for the group has not yet reached satisfactory stability. This is not surprising, considering the comparatively few studies that have been carried out on morphological features of tentaculitids. It is only in Ljashenko (1959), Bouček (1964), Blind (1969) and Lardeux (1969) that more comprehensive treatments have been given. Most other recent papers have merely referred to these studies without adding any new data on morphology.

The majority of modern studies on tentaculitids have been published in Russian, German and French, with only very few in English. English nomenclature for many morphological characters remains especially heterogeneous or is non-existent. Several non-English terms are difficult to translate concisely. Most papers, whatever their original language, have given poor definitions with few or no accompanying illustrations. Discussion of morphological features has involved lengthy and diffuse descriptions, yet few unambiguous terms have been introduced. This has certainly not simplified study of tentaculitids.

To improve the nomenclature, I am here introducing special terms for all significant morphological characters of the tentaculitid conch. The nomenclature includes a selection of relevant terms already introduced for tentaculitids as well as terms used for other invertebrate fossil groups, such as cephalopods, gastropods and brachiopods. Usage of the latter set of terms does not imply any interpretation of the zoological affinity of tentaculitids. I have tried as far as possible to use neutral terms to define properly the various morphological characters. I see no disadvantage in applying terms used for other fossil groups if terms designate characters of similar appearance and function. It will undoubtedly be simpler to memorize such terms. To describe the morphology of the rings I have applied some terms normally used by structural geologists for folds.

The morphological characters of the tentaculitid conch and their names are illustrated in Fig. 6.

The tentaculitid conch

The hard calcium carbonate exoskeleton, here termed the *conch* secreted to protect and support the soft tissue of the tentaculitid animal forms the fossil remains. It comprises an external, single gradually tapering conch with conical shape, elongate, mostly straight, closed at the narrow end and open at the wide end. Internally it may be divided in the narrow portion by transverse partitions, septa, of various shapes and numbers, while the wider part of the shell comprises the living chamber. In the conch wall, a *primary shell* comprising only the outermost laminae of the conch and a *secondary shell* comprising the septal structures and the internal laminae of the wider part can be distinguished. In general these two divisions of the conch are clearly separated from each other by certain characteristic features of the wall.

It is important that the tentaculitid conch shows no evidence of any attachment surface to indicate firm contact with the substrate. Thus, there is a fundamental difference in this respect from other tubiform and ornamented fossils of similar shape and size which occur concomitantly in the beds studied, i.e. members of the enigmatic fossil group of cornulitids.

Composition and microstructure

The following description of the basic microstructures is based mainly on observations made from routine SEM work, but also on examination of sectioned material using an ordinary light microscope. Some information from recent literature is integrated.

The papers by Lardeux (1969) and Blind (1969) have given a fairly good outline of the basic composition and construction of the tentaculitid conch. Already in 1883 Dewitz had described the conch wall as multi-laminated, with alternating calcitic and organic layers (Dewitz 1883). However, the arrangement of the calcite crystals has been a matter of confusion because of the use of different terms. The structure was described by Dewitz (1883) and Gürich (1896) as lamellar, Bøggild (1930) as foliated, Fisher (1962) as prismatic and Bouček (1964) as fibrous. That the wall structure is clearly lamellar was demonstrated by Ljashenko (1959), Lardeux (1969) and Blind (1969), and is also evident from the present study. It has been demonstrated convincingly by Blind (1969) that the primary shell is composed of three principal layers: an outer organic layer, a calcitic micro-lamellar layer constituting the bulk of the shell, and an inner organic layer. The present study corroborates this and, further, shows that the secondary shell has a similar construction.

The outer organic layer is generally difficult to distinguish because it is very thin and tends to be removed easily. It may sometimes be observed in a scanning electron microscope (SEM) (Fig. 31D), but generally the etching process produces sharp relief between the shell and the surrounding medium and this hampers good observation of the layer. In the few cases where it has been definitely identified, it can be observed as a thin transparent film. The conch should be immersed in an etching medium, preferably EDTA, in which the layer becomes slowly removed from the conch as the calcitic laminae gradually dissolve. It has not been possible to gauge reliably the thickness of the outer organic layer, but Blind (1969: 112) reported a thickness of 1 μm or less, which seems reasonable.

The basic units of the calcite layers are tabular calcite crystals, most of which show irregular, jagged outlines (Fig. 7F). Few crystals with a clearly hexagonal shape have been observed (Fig. 7A–B). The irregular crystals have uneven surfaces which commonly appear pitted (Fig. 7C). The well developed hexagonal crystals show distinct facets, on which a faint verrucosity may be seen. The calcite tablets in the outermost laminae are disposed parallel to the surface of the conch. In section they appear as lenticular, irregular discs (e.g., Fig. 23A). It is probably this view which led Bouček (1964) to describe the crystal structure of the conch as fibrous. The calcite tablets lie close to each other and subparallel. The stacking of the calcite tablets is not regular. They overlap each other to various degrees, mostly with the facets of the crystals forming the contact surfaces. The tablets amalgamate laterally to various degrees to form a succession of plates. These can be clearly seen when the tablets are viewed from above (Fig. 7D, F).

Intercrystalline organic membranes are very rarely

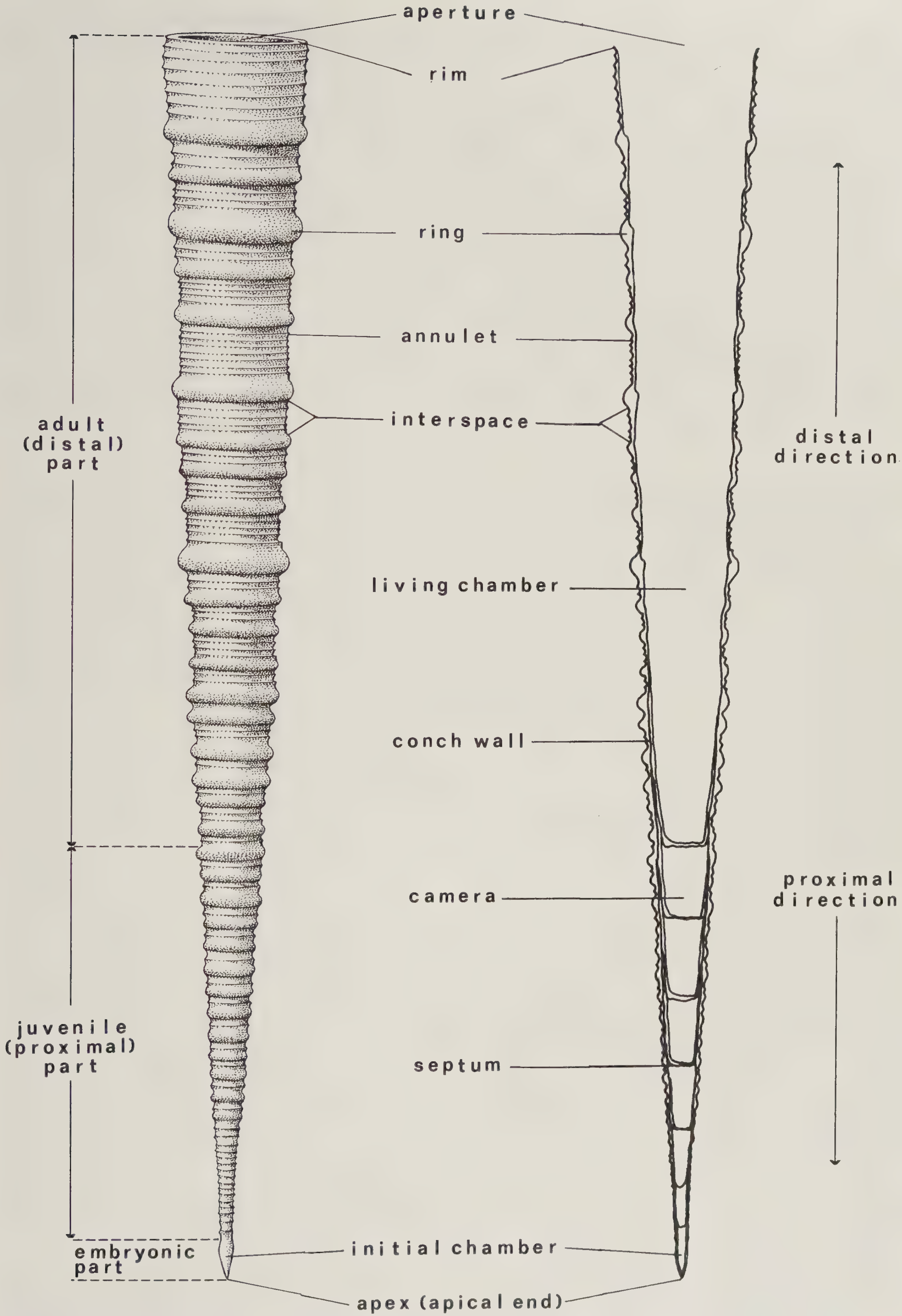
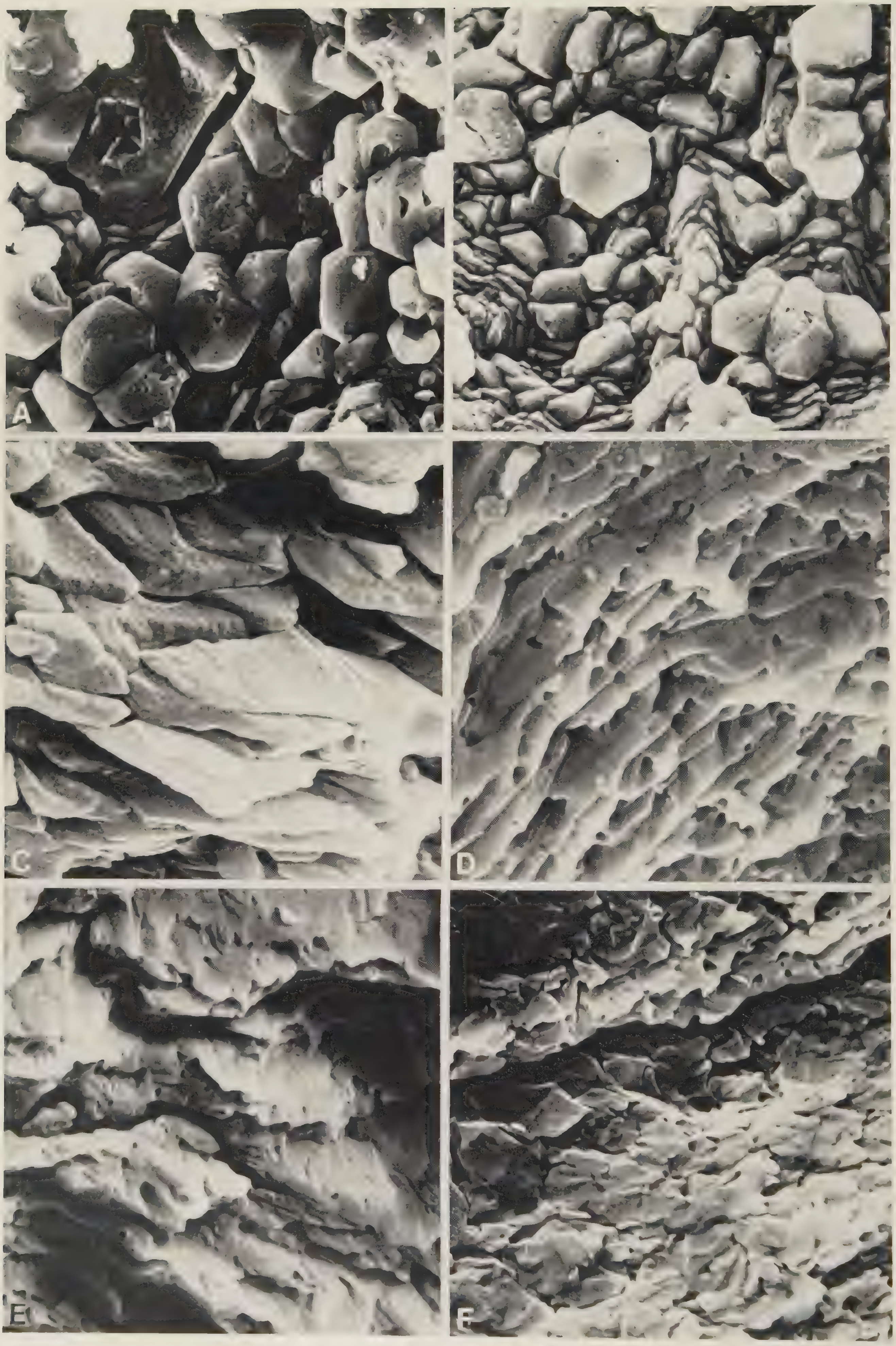

aperture
rim
ring
annulet
interspace
adult
(distal)
part
distal
direction
living chamber
conch wall
camera
proximal
direction
septum
juvenile
(proximal)
part
embryonic
part
initial chamber
apex (apical end)

Fig. 6. Schematic figures of the exterior and interior of the tentaculitid conch to illustrate the morphological terms used.


A
B
C
D
E
F

visible. Only one specimen has shown how parts of the inner organic layer penetrate partly between the tablets (Fig. 10B).

The shape of the crystals in the calcite layers of tentaculitids led Blind (1969: 116) to compare the structure with the nacreous layer developed in certain molluscs. He described the crystals as varying from rhomboidal to pseudohexagonal, with more of the former type. He interpreted this to result from a diagenetic phase transformation of the crystal form from aragonite to calcite. The rhomboidal crystals were regarded as residual products from unstable aragonite crystals which had formed the nacreous layer of the tentaculitid. This interpretation seems improbable; to may own and others' knowledge (V. Jaanusson & H. Mutvei, personal communications, 1978), no cases are known where a conch which consists of calcite preserves in detail the original aragonitic microstructures. All tentaculitid conchs sectioned in this study show unaltered microstructure and no signs of a phase transformation from aragonite to calcite have been seen (cf. Towe 1978: 626). Any possibility of a nacreous layer in tentaculitids is undoubtedly excluded.

Recently Towe (1978, Fig. 1d–f) demonstrated by transmission electron microscopy a laminated structure of the calcitic layer known as cross-bladed fabric (Armstrong 1969). The observation is interesting because this structure is otherwise restricted to certain articulate brachiopods. It thus has bearing on the question of affinity which is discussed in a later chapter (p. 59). I can neither confirm nor deny from my material the existence of a cross-bladed fabric of the calcitic layer. I used another type of preparation technique and scanning electron microscope.

The tabular crystals are of various sizes. Their thickness is relatively uniform, 0.001–0.002 mm. Diameters are more variable, with a size range from a few μm up to 0.015 mm and an estimated average value of 0.005–0.01 mm. A few specimens show some difference in the size of tablets on the outer and inner sides of the conch, with smaller tablets forming the inner surface of the living chamber. However, more material is required if firmer conclusions are to be drawn.

A very conspicuous feature of all tentaculitids studied is the presence of one or more, normally 2 or 3, pores in each tablet. Mostly, these pores are located in the central part of the tabular crystal. They are arranged more or less parallel to the surface of the tablet and are directed similarly in all adjacent tablets. This is especially well seen on fractured surfaces with the tablets in oblique view (Fig. 7D). The pores are rather straight and penetrate the crystal for a considerable distance (Fig. 7D–E). It is not certain if they penetrate right through the tablet or only through part of it. The diameter of the pores is about 0.001 mm. It is difficult to elucidate the function of these pores but they give the tentaculitid conch, even in minute fragments, a distinctive appearance. These pores are certainly primary structures and not artifacts originating from etching processes, because they occur constantly in all kinds of conchs, even on freshly fractured surfaces (Fig. 7D–F).

The tabular calcite crystals compose *lamellae* which represent distinct growth phases. The lamellae in section are seen to be separated from each other by dark lines (Fig. 22), which Lardeux (1969: 21) explained as optical phenomena. However, it is more likely that they represent very thin organic envelopes around the lamellae, analogous to structures of the brachiopod shell (cf. Williams 1968). Many SEM micrographs show a distinct separation between successive lamellae, with ample space for an organic layer (e.g. Fig. 23A). Some sectioned conchs show remnants of the organic layers in place between crystalline lamellae. Such occurrences are rare, but refinement of the preparation technique will undoubtedly allow this feature to be studied in more detail. The lamellae are not persistent along or around the conch. They rather form units of various lengths which are accreted inwards onto each other from the outermost, primary, set of lamellae. Thus, these units form a series of incomplete cones tightly inserted into each other (e.g. SEM micrographs, Figs. 56H). This construction of the shell is clearly demonstrated in conchs which have been repaired after damage (a common phenomenon in all taxa investigated), as in Figs. 18 and 19.

Bouček (1964), who primarily studied dacryoconarids, distinguished two principal layers in the conch. The outer of these should have lamellae secreted outwards. The number of lamellae was greater in Silurian than in Devonian tentaculitids. Subsequent studies have not corroborated his conclusions. Lardeux (1969) and Blind (1969) demonstrated convincingly that secretion of the lamellae is directed towards the interior of the conch, and Lardeux (1969) found a similar thickness of the conch for Silurian and Devonian tentaculitids.

The outermost lamellae in the interspaces are parallel to the outer surface. However, towards the interior of the rings the lamellar orientation becomes increasingly different from that of the outermost lamellae. There is greater accretion in the proximal part of the rings so that the shape of the living chamber becomes modified. The amount of thickening determines the magnitude of the flexure between the interspace and the proximal limb of the ring. The flexural size seems to have some taxonomic importance. Before the inner organic layer is secreted, the central part of the rings is more or less filled by thick, strongly lenticular lamellae. Hence, secondary shell is not entirely responsible for smoothing the inner wall surface (Fig. 61E–F) and most smoothing may occur during a comparatively early stage of growth. The laminae of the secondary shell are commonly discordant with those of the primary shell (Fig. 31C).

There have been long discussions in the literature about the dark lines seen in section, which lie

Fig. 7. Calcitic conch wall. ☐ A, B. Calcite tablets of the mural parts of septum, both ×2.500. *Lonchidium scanicum*, SMNH X 1578; Bjärsjölagård 2, Bj 71-2 KL. ☐ C, calcite tablets of the primary shell, ×8.500. *Odessites petilus*, SMNH X 1402; Lunnarna 2, Lu AM-2. ☐ D, E, F. Oblique views of the calcite tablets of the primary shell, all ×3000. Note the pores penetrating the tablets. *Volynites muldiensis*, SMNH X 1227; Mulde Tegelbruk 1, MS 10/1960: V.

perpendicular to the surface and penetrate through part or the whole of the conch wall. The dark lines were interpreted as perforations and termed "canals" by Ljashenko (1959, 1969), who used them as a taxonomic criterion at order level. Lardeux ("black lines" – 1964; 1969, Fig. 13, Pl. 8) and Blind ("pseudopores" – 1969: 114–115, Pl. 13: 1–2) suggested that the dark lines were merely phenomena of optical deflection resulting from the arrangement of the lamellae. Lardeux (1969; Pls. 10: 1; 11: 1–2) showed the "black lines" penetrating the entire conch wall and also through the mural parts of the septa. Blind explained the lamellar structure as composed of minute, superimposed, inward-facing cones. He reported these structures to occur only in the outer part of the calcite layer and showed (1969: 115, Pl. 13: 3) them terminating at the inner wall surface as minute, conical structures which he called *Höckerchen* (small knobs). Blind's structures were 0.005–0.006 mm in diameter and about 0.004 mm high. He found the minute cones only in the adult part of the conch, increasing in abundance towards the distal end. He tentatively suggested a function in the attachment of muscles controlling an operculum and tentacles. However, in spite of the papers by Blind (1969), Brassel *et al.* (1971), and Blind & Stürmer (1977), the evidence remains ambiguous and therefore this interpretation must still be regarded as mere speculation.

There was no arrangement of the calcite lamellae of the kind just described common to all material investigated here. Material from Gotland was particularly variable. Silurian tentaculitids seem to differ in this respect from Devonian tentaculitids. The latter commonly show a crescentic lamellar arrangement in longitudinal section (cf. Lardeux 1969; Ljashenko 1959, 1969a–d), but it is clear that there is a taxonomic relationship. This can explain the difference between Silurian and Devonian material. The lamellae of Gotland species of the genus *Alternatus*? are buckled in a particular, consistent pattern. The same pattern may also be seen in several other genera, e.g. *Tentaculites, Turmalites, Odessites,* and *Lonchidium.* These structures are more common in Scanian than in Gotland material, especially among the stratigraphically youngest representatives.

The wavy profile of the laminae just described reflects the adjacent sets of superimposed cones composed of stacks of buckled lamellae (Fig. 8). The apices of cones are directed inwards. Many sets penetrate the entire wall surface and terminate at the internal surface of the conch as small elevated cones (Fig. 8A, C).

The sets of superimposed cones described are remarkably similar to pseudopuncta of many articulate brachiopods. The small cones seen on the inner surface of the tentaculitid conch resemble the tubercles found at the end of pseudopuncta in brachiopods. Without implying any relationship between the two animal groups I propose the use of *pseudopunctum* (plur. -a) and *tubercle* for the designation of similar structures seen in tentaculitids. In the tentaculitid pseudopuncta, no structures resembling the taleolae of many pseudopunctate brachiopods have been observed. Thus they appear like pseudopuncta of certain strophomenaceans and gonambonitaceans and many davidsoniaceans. The pseudopuncta are mostly in the proximal limbs of the ring. In some species there are also well developed pseudopuncta in the distal limbs (*Tentaculite scalaris,* Fig. 33E), or in the interspace walls (e.g. in *Alternatus*?, Fig. 8D).

The pseudopuncta are always perpendicular to the wall surface, either straight or slightly curved towards the interior of the conch. The latter mode is found especially near a ring (Fig. 8A). The change in direction follows that of the inner wall surface of the proximal limb. The conical shape of the buckled lamellae is most pronounced in the outermost part of the conch wall. The cones are gradually flatter inwards across the wall (Fig. 8A–B). In some conchs, the pseudopuncta penetrate not only the primary shell but also affect the mural parts of the septa. The shape of the cones is impressed through the inner, covering organic layer into the inner surface of the septum (Fig. 8D). This observation is supported by illustrations in Lardeux (1969; Pls. 10: 1; 11: 1–2) and Blind (1969; Pl. 13: 1).

The pseudopuncta are generally well spaced. A separation of 0.01–0.025 mm and density of 50–60 pseudopuncta per 0.01 mm^2 are common. Such a density is similar to values calculated e.g. in Lardeux (1969, Pl. 9: 2) for some Devonian species. However, many species show much lower densities of pseudopuncta. Also, density varies within a specimen, the number of pseudopuncta increasing in successive rings.

The height of the pseudopunctal cones close to the outer surface of the conch is 0.004–0.005 mm. Well developed tubercles have only been seen in a few specimens because internal surfaces of conchs are rarely exposed and are difficult to clean matrix from properly.

Progressive diminution of lamellar buckling is a feature of all pseudopuncta. This might be explained by ontogenetic change in the functional morphology of the inner proximal surfaces of the rings. The highest tubercles always form close to the aperture and they are gradually shorter proximally. The decrease in size reflects accretion of new laminae near the aperture as the animal grows. Ultimately, tubercles located in the proximal part of the body chamber will become completely covered and there will be a smooth internal surface.

The limited amount of material with tubercles restricts consideration of their function. However, in members of the genus *Alternatus*?, which have poorly developed rings and hence only moderate annular deflections of the conch wall, pseudopuncta are very well developed. If it be assumed that the internal wall of the rings, especially the proximal part, is an attachment surface for soft tissues (Blind 1969: 115), it is tempting to explain the numerous tubercles in *Alternatus*? as serving to increase the surface area for attachment. Many tentaculitids with very well developed rings, e.g. *Odessites inflatus,* have few or no pseudopuncta. Many species with flatter rings and correspondingly smoother internal surfaces to the rings, have a higher frequency of pseudopuncta, as e.g. *Lonchidium ogmotum.* However, this hypothesis is inapplicable to some other genera, like *Tentaculites.* Many species of this latter genus have very prominent rings.

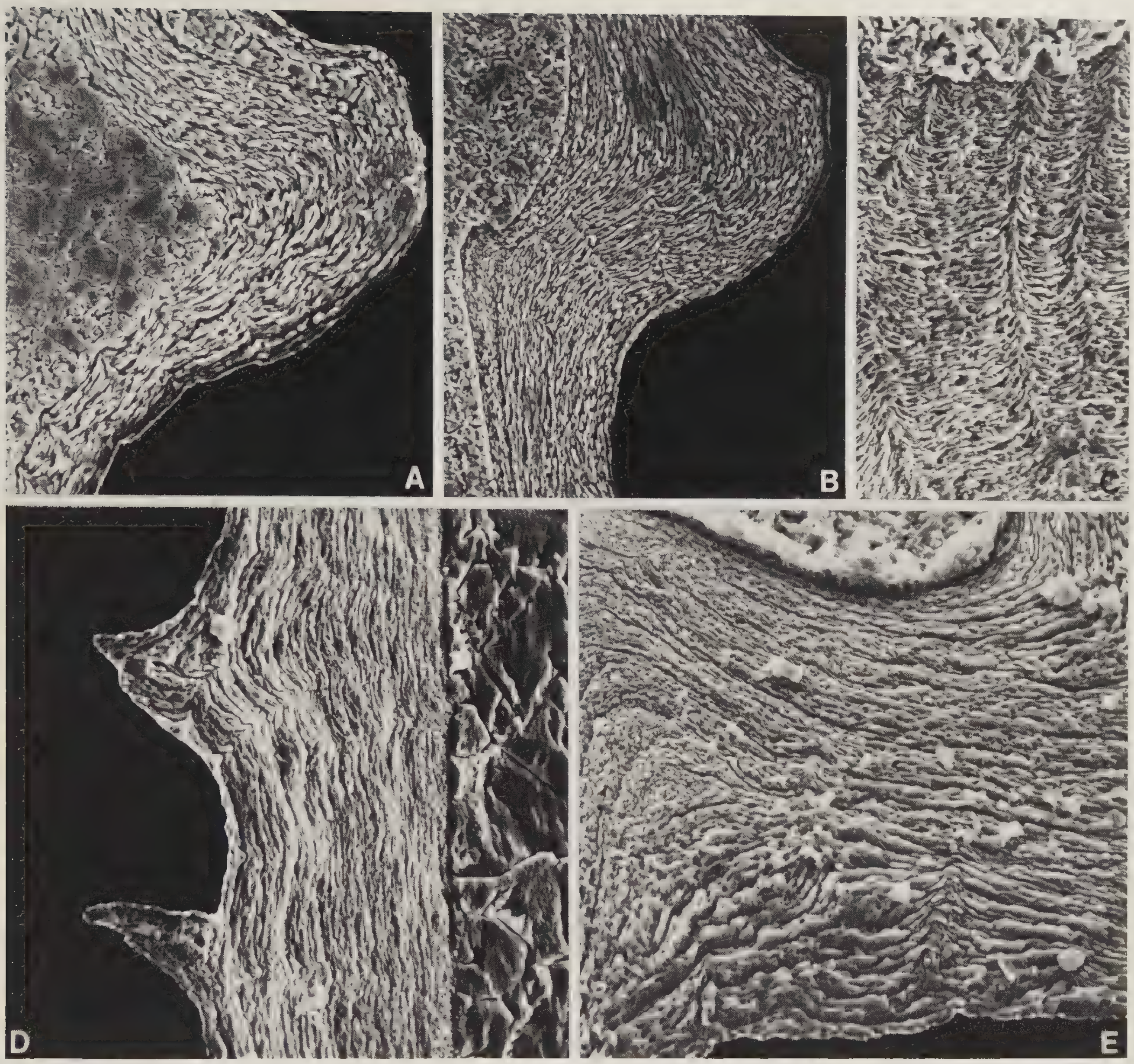


Fig. 8. Pseudopuncta. ☐ A, B. *Odessites portensis,* SMNH X 1688, × 400 and × 300; Klinta 4, Kl 67–32 LJ. ☐ C. *Tentaculites scalaris,* SMNH X 1652, × 1000; Ramsåsa 2, Ra 71-3 KL. ☐ D. *Alternatus?* sp., SMNH X 1679, × 500; Mulde Tegelbruk 1, MS 10/1960: XI. ☐ E. *Volynites scalpratus,* SMNH X 1275, × 900; Mulde Tegelbruk 1, MS 608.

Some, such as *T. hisingeri* (Fig. 28D), have distinct pseudopuncta in the proximal limbs; other, like *T. scalaris* (Fig. 33E), have them also in the distal limbs. A possible explanation for the exceptions would be as follows. These species are comparatively large, with wide, long living chambers, so the soft parts may have been relatively voluminous. Then, more sophisticated attachment structures could have been required.

Another explanation for the function of the pseudopuncta and tubercles would be as strengthening devices for the conch wall. Such a function may be inferred for pseudopuncta in some articulate brachiopods with weakly convex shells (V. Jaanusson, personal communication, 1978). It would also explain why tentaculitid pseudopuncta are mostly in the proximal limbs of rings, where the conch wall is thinnest.

The inner surface of the primary wall is covered by an organic layer. This organic layer is much thicker than the outer one, and is easily seen in many SEM micrographs (Figs. 9–10). It may attain a thickness of 0.01 mm, but is usually only 0.001–0.003 mm thick. Even in one specimen the thickness may vary considerably, both transversely (Fig. 61F–G) and longitudinally (Fig. 57C). The inner organic layer (Fig. 61F) is not structureless. Some minor dark longitudinal bands can be distinguished but they have not been closely examined. The surface of the layer may show imprints of the calcitic lamellar tablets (Fig. 10B). Formation of the inner organic layer during ontogeny comes before the secretion of septa and after some accretion of calcite laminae in the ring areas to smooth out the internal wall surface (Fig. 10C–D). Thicker organic layers continue to form throughout septal secretion. In some species thick organic layers alternate with the calcite laminae which form the septa (Fig. 10E).

Intercalation of organic layers between septa produces a characteristic banding in this section (Fig. 60C). However, it is also common that the organic layers separating septa are extremely thin, or lacking so that adjacent laminae lie directly in contact (Fig. 24G). In all species, the inner organic layer forms a distinct boundary between primary and secondary shell, and it may be seen easily both in thin section and in SEM micrographs. Longitudinal cracks in the primary shell, which commonly form during preparation of sections, may easily be mistaken for the inner organic layer, especially if it is thin. Such cracks, however, usually have an irregular, laterally variable course (Fig. 26D).

The composition and microstructure of the primary and secondary shell are similar. The secondary shell has the same tripartite structure but the thickness of the organic layers are very variable. It may be difficult to distinguish the outer organic layer of the secondary shell if it has amalgamated with a thick inner organic layer of the primary shell. In some SEM micrographs the inner organic layer is very distinct, with pronounced relief above the etched surface (Fig. 10C–D). With very thin septa it is obvious that the organic layers represent most of the total septal thickness (Fig. 58D); there may be no calcitic component.

A fairly different construction of the conch wall was reported for dacryoconarid tentaculitoids by Alberti (1975). He recognized three principal mineral layers, the outer prismatic, central nacreous, and inner prismatic layers. The central nacreous layer was interpreted to consist of pseudohexagonal aragonite crystals (Alberti 1975, Pl. 1: 2). This is different from the construction found here for the thick-walled tentaculitoids. There could be a fundamental difference in wall construction among the three tentaculitoid orders. This would certainly influence taxonomy of tentaculitoids. However, it should be emphasized that Alberti's observations were from only one conch of a *Styliolina* species, and thus conclusions should not be drawn too far. Further proof that aragonite is involved is required. Alberti (1975: 506) regarded his find as support for the molluscan affinity of dacryoconarids, with a systematic position rather close to the cephalopods.

Orientation of the conch

The conventional pose for illustration of a tentaculitoid conch is with the axis vertical and narrow end down.

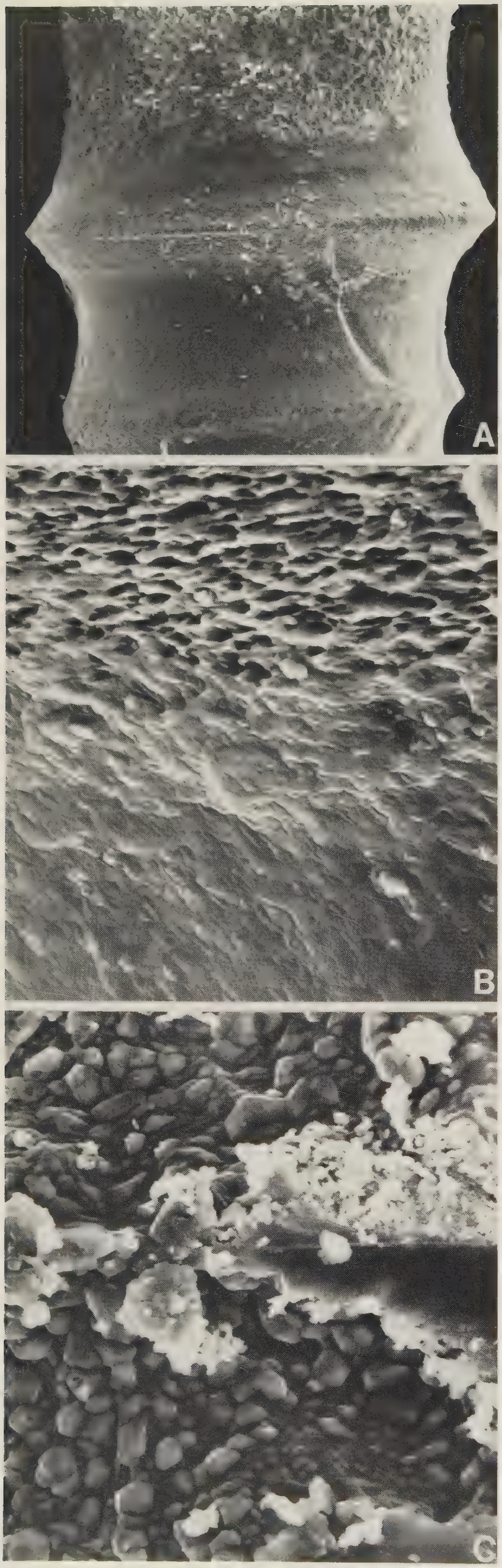


Fig. 9. External view of inner organic layer. ☐ A, B. Lateral view of distal ring, × 75, and detail of contact of inner organic layer and calcitic laminae filling the annular concavity, × 1000. Etched specimen of *Volynites muldiensis,* SMNH X 1228; Mulde Tegelbruk 1, unnumbered SMNH sample. ☐ C. Longitudinal section showing contact of inner organic layer and mural parts of septa in *Lonchidium scanicum,* × 1000, SMNH X 1578; Bjärsjölagård 2, Bj 71-2 Kl.

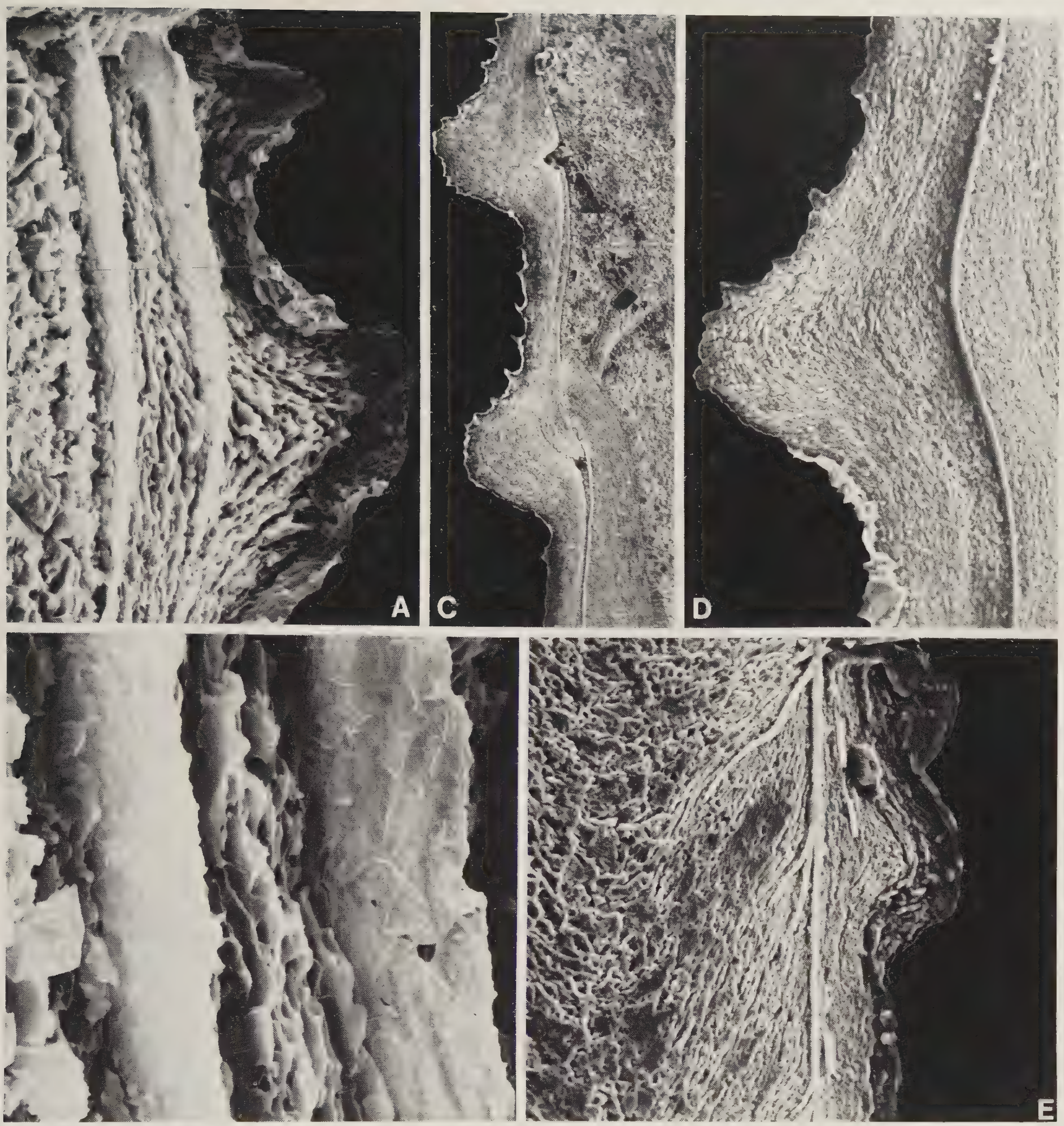


Fig. 10. Longitudinal sections of conch wall illustrating the inner organic layer. ☐ A, B. Inner organic layer in the distal conch, × 750, and detail, × 2500. Note in B the pitted imprints of the calcite tablets on the organic layer. *Dicricoconus cracens,* SMNH X 1289; Mulde Tegelbruk 1, MS 608. ☐ C, D. Inner organic layer in the distal septal region, × 100, and more proximally, × 300. *Tentaculites scalaris,* SMNH X 1660; Ohesaare Pank, Estonia, unnumbered SMNH sample. ☐ E. Inner organic layer in the septal region of *Tentaculites obstipus,* × 300. Note the branching of organic layers between the endoconic septa. SMNH X 1424; Kullunde 3, Got 76-31 SB.

However, in Ljashenko's papers and in Fisher (1962) the apical end is up. This reflects the difference in opinion about the life position of the tentaculitoid animal and its zoological affinity. Here the conventional orientation is preferred. It facilitates comparison with most other illustrations.

The tentaculitoid conch has *bilateral symmetry.* This is easily discerned if the conch is curved, which is especially characteristic of the extreme proximal part. Bilateral symmetry may be shown by the living chamber, the proximal end of which is often inclined to the long axis (Fig. 52E). Definite evidence for this symmetry was presented by Lardeux (1964, 1969: 11, Fig. 2, Pl. 4: 1–5), who demonstrated a central furrow lined by a series of small tubercles in internal moulds of the living chamber of *Volynites velaini* (Munier-Chalmas). The proximal part of the furrow was bounded by two symmetrical, crescent-shaped, slightly elevated platforms which were delimited laterally by faint furrows. The features represent negative imprints from structures developed on the inside of the conch wall. Such structures are rare; no similar features have been described since. However, one of the localities described here, Ramsåsa 8 in Scania, yielded abundant phosphatized material including moulds with similar imprints of the internal conch wall. These structures will be discussed later (p. 37).

In spite of Lardeux's important and convincing evidence for bilateral symmetry, some authors still support a radial symmetry for the tentaculitid conch. Berger (1974: 137, foot-note) emphasized radial symmetry because the tentaculitid conch does not show any surface characters to distinguish one side from another. This is true of the surface of the juvenile and adult parts, and for that reason terms like dorsal, ventral, and lateral cannot be applied. However, the curvature nearly always present in the proximal part precludes radial symmetry. In many tentaculitid taxa the morphology of the initial chamber provides additional support for bilateral symmetry. The chamber is triangular and equilateral in one view. However, perpendicular to this orientation, it is asymmetrical, with one comparatively flat surface opposite a convex surface (Fig. 11C–D).

The conch may be divided to reflect various ontogenetical stages. The narrow end is the earliest formed, *embryonic part.* It consists of the *initial chamber,* which in many taxa has a characteristic morphology and which is one of the basic characters for taxonomic division at family level. The proximal end of this chamber is called the *apex* or *apical end.* The adjacent region is the *juvenile* or *proximal part,* where the conch expands. In thick-walled tentaculitoids it is divided internally by septa. The major portion of the conch comprises the *adult* or *distal part,* which is the living chamber. In most species it expands slightly or is subcylindrical in shape. A fourth division, the *apertural* region, has also been distinguished in some papers (e.g. Ljashenko 1959). That the conch becomes thinner close to the aperture may have influenced some authors to distinguish this region. However, I find it a superfluous division because the aperture is a morphological character present in every ontogenetic stage. It does not form an ontogenetic stage of its own. Some adult specimens develop a particular ring pattern at the extreme distal end. This area is here considered to represent an advanced stage of the adult part and could, if growth had continued, have been followed by new rings. Such distal ring patterns are especially well seen in specimens of *Volynites muldiensis* (Fig. 56A). Lardeux (1969) distinguished an intermediate region between the juvenile and adult parts. I feel this division is difficult to define morphologically. A tripartite division related well to the morphology of the conch.

Mostly the initial chamber is easily distinguished. The chamber may be slightly drop-shaped, bounded by a weak constriction, or it may taper more steeply than the juvenile part. In most tentaculitids there is a pronounced decrease in growth angle of the conch at the last septum. This may be regarded as the transition between the juvenile and adult stages. Here, also, the ring pattern usually changes and pseudopuncta appear. It is admittedly difficult to delimit these regions exactly for all species, particularly when there are gradual transitions. Even within a species considerable variation may occur.

In description of the various morphological characters the terms *proximal* and *distal* will be used. Proximal refers to the direction of the apex and distal towards the aperture (Fig. 6).

Shape and size of the conch

The tentaculitid conch is conical, closed at the narrow end and open at the wide end. The conch may be straight or curved. The adult part is usually straight. In several species, the juvenile part is curved, either along the entire length or just the proximal part by the initial chamber. In some species curvature is confined to the initial chamber. Conchs straight along most of their length are termed *orthoconic.* Those markedly curved for most of their length are termed *cyrtoconic.* Few cyrtoconic tentaculitoids have been described. Bouček (1964: 23–24) discussed curvature among tentaculitoids briefly. He considered it to be an occasional feature of some species (e.g. in *Homoctenus jaregae* Ljashenko). He also noted curved conchs in a limited number of one population and this curvature he considered to be teratological. However, I have studied very large populations of markedly curved tentaculitids from the Visby and Högklint Beds of Gotland. Herein, these are referred to the new genus *Gotlandellites* within the new family Gotlandellitidae. Curvature of the conch is a constant feature of specimens, and it distinguishes this family from all other families within the order Tentaculitida. Thus, I cannot agree with Bouček's conclusions.

The cross-section of the conch is usually circular. The only exceptions are species with a drop-shaped initial chamber which is subtriangular in cross-section.

The conch generally shows at least two principal points of expansion. From the narrow part, the conch expands more quickly than at the wider, more distally located, part. The growth angle at the former point is termed *proximal growth angle* (PA) and that at the latter the *distal growth angle* (DA). The proximal growth angle, which corresponds to the apical angle of previous authors, may range between 2 and 13°, but is generally 4–6°. The distal growth angle may range from less than one degree up to 4°. The distal parts of many species are subcylindrical. I have avoided the term apical angle to describe the expansion of the juvenile stage because the earliest juvenile portion, immediately behind the initial chamber, is commonly subcylindrical. Furthermore, the initial chamber is generally more steeply conical than the adjacent juvenile part. The true apical angle should then, by definition, belong to the initial chamber. Unfortunately the initial chamber is very seldom preserved. What has been described as the apical angle is in reality the rate of expansion more distally, in the septal region of the conch. This is the part most often found intact and which can easily be measured. In many papers the proximal growth angles are expressed in fractions of a degree. I have found the greatest level of measurable precision to be to

0.5°. In the numerical tables following each description, the proximal growth angles are expressed to this accuracy.

The full adult size ranges from 4–5 mm to 25–30 mm. Tentaculitids less than 10 mm long are termed *small-sized,* those between 10 and 20 mm *medium-sized,* and larger than 20 mm *large-sized.* These categories conform to those proposed by Ljashenko (1969a–d). They are arbitrarily chosen but convenient for the material studied. After comprehensive treatment of material from several areas more statistically significant size classes may be defined.

The diameter of the narrow end of the conch is seldom less than 0.05 mm. Unfortunately though, few apical ends are preserved intact. Normally conchs are found broken off at diametres of 0.10–0.15 mm. When the initial chamber is still attached, the outer diameter of the conch adjacent to the chamber is commonly 0.08–0.10 mm. Most of the species studied attain distal diameters of 0.90–1.10 mm. Really large specimens, as in *Tentaculites hisingeri* and *T. scalaris,* may have outer distal diameters of 2.0–2.4 mm.

Embryonic part

The embryonic part is rarely conjunct with the rest of the conch. Not many isolated embryonic parts have been found. For several species these could not be identified. The initial chambers in various species of the same genus are morphologically similar. This complicate matching of chambers to species.

Several types of initial chamber occur. In general, the type has been regarded as significant for distinguishing tentaculitoids at order level. In the Tentaculitida the initial chamber is normally conical with a more or less transitional passage to the juvenile part. There is no constriction nor other morphological feature delimiting the initial chamber. However, this type of initial chamber should probably not be regarded as characteristic of the Tentaculitida. There are some papers, e.g., Ljashenko (1969) in which new genera erected in this order have asymmetrical initial chambers separated from the rest of the conch by a faint constriction e.g. *Parvulites* (Ljashenko 1969a, Pl. 7: 3–4). These genera are otherwise typical of Tentaculitida. Rather than refer these genera to new orders, I would prefer to accept some variation in the morphology of the initial chamber. This feature may be more diagnostic at family level.

The few initial chambers found are of two main types. One type comprises a conical chamber which grades into the juvenile part without any marked constriction between. The apex of the chamber is rather pointed. This type occurs in e.g. the genus *Tentaculites* von Schlotheim. Because there are no external features which delimit the chamber, measurements are difficult to make. In some species, it was only possible to measure the outer diameter of the distal part.

The second type of initial chamber is well differentiated and bilaterally symmetrical. It is triangular in view along the sagittal plane. Perpendicular to this plane it shows one slightly curved side and the other flatter (Fig. 11C–D). The apex is somewhat elongated. There is good evidence to assume that there has been a subcylindrical extension forming the point (cf. Fig. 11E–F). Unfortunately all initial chambers have this part broken off. The distal part of the chamber may be entirely smooth or may have one or two asymmetrical rings which lie very oblique to the long axis of the chamber (Fig. 11D). The subsequent rings are believed to belong to the juvenile conch. They also lie obliquely, but progressively less so until they are perpendicular to the axis. In many species there is a faint constriction of the conch after the two very oblique rings. The constriction is regarded as the distal limit of the initial chamber. At the constriction the cross-section of the conch is circular.

The definition presented here is founded on the belief that the change in ring morphology after the first two and in shape of the conch indicates a new stage in the ontogenetic development. There is also commonly an abrupt change in the direction of the long axis of the conch at this point (Fig. 11J).

The first septum was used to define the distal limit of the initial chamber by Ljashenko (1959, Fig. 8) and Blind (1969, Fig. 6). However, it is not known whether the position of the first septum is before or after the embryonic rings. None of the embryonic parts sectioned have shown septa. The first septum is probably more distal because the formation of septa takes place rather late during ontogeny. This was demonstrated by Lardeux (1969: 187–188, Fig. 148) and was seen in the present study. Hence, the position of the first septum cannot be used to delimit the initial chamber.

One sample (Gothemshammar 1, sample MS 895) shows some variation in the widths and lengths of the initial chambers and the obliquity of the embryonic rings. The length is commonly 0.15 to 0.20 mm, the distal diameter 0.10–0.15 mm, and the proximal diameter 0.01–0.02 mm.

The wall of the initial chamber, like that of the later stages of the conch, is clearly lamellar. The thickness is uniform so the interior surface parallels the outer shape (Fig. 11G). The mean thickness is about 0.01 mm.

Juvenile part

In adult specimens, the juvenile part comprises the portion of the conch from the initial chamber to the last septum. At this latter level the growth angle and annulation change. In many tentaculitids the most proximal juvenile part, after the initial chamber, expands at a low angle and so has a subcylindrical shape. The length of this portion ranges between 0.1 and 0.3 mm. This portion is often more curved than the following juvenile shell. The main part of the juvenile conch expands rather constantly, at an angle between 3 and 13°. The proximal growth angle is fairly diagnostic for species. The juvenile part normally constitutes about 20 to 30% of the total conch length. In some specimens of *Tentaculites hisingeri* the juvenile part comprises almost 40% of the total length.

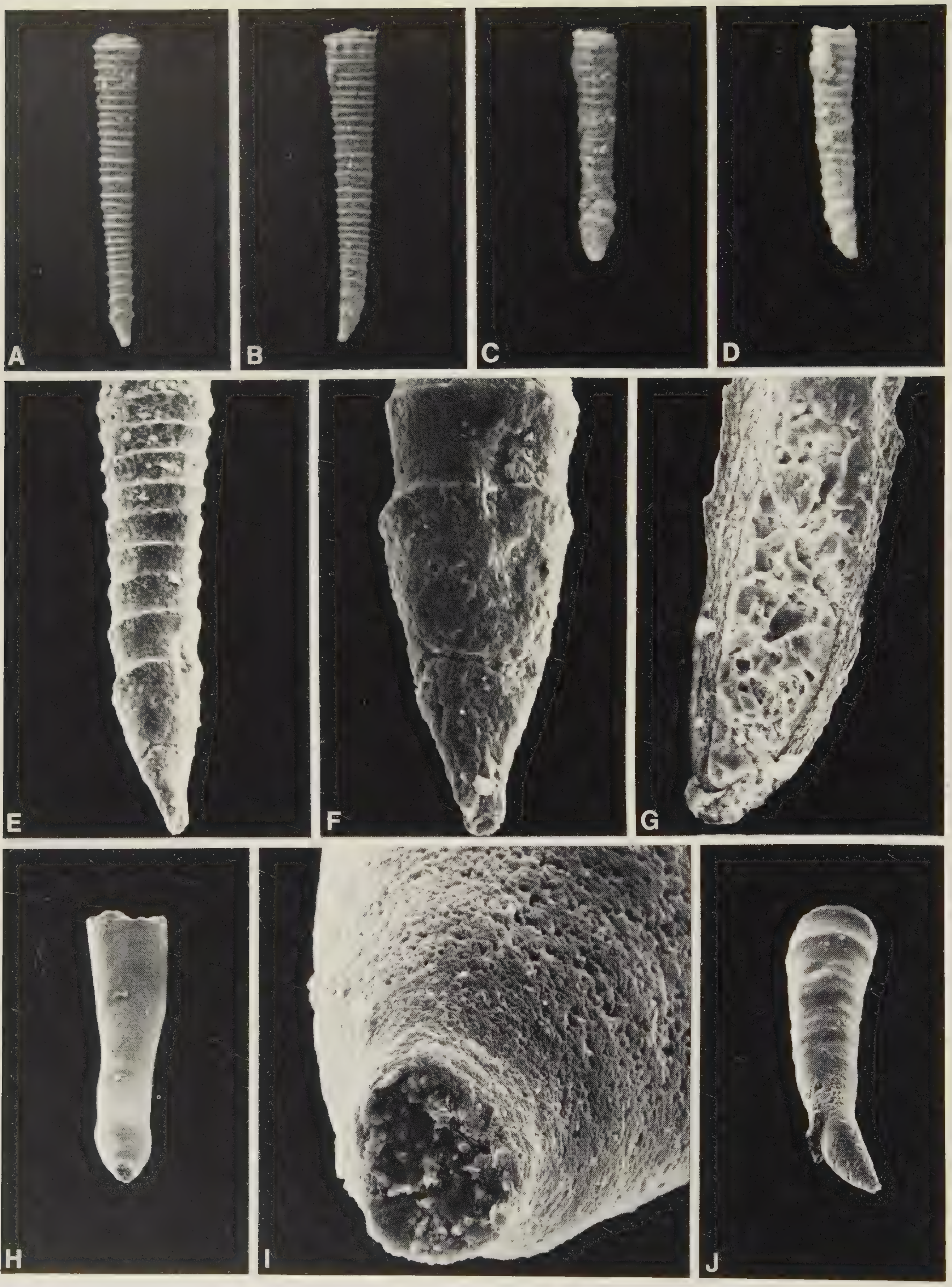


Fig. 11. Initial chambers. ☐ A, B. *Odessites majstriensis,* views perpendicularly opposed, both ×40. SMNH X 1575; Majstre 1, Got 76-44 SB. ☐ C, D. *Odessites prolatus,* views perpendicularly opposed, both ×50. SMNH X 1699; Petsarve 9, Got 76-15 SB. ☐ E, F. Initial chamber and early proximal part, ×115, and detail of former, ×500. *Podolites hedei,* SMNH X 1181; Gothemshammar 1, MS 669. ☐ G. Longitudinal section of initial chamber, ×300. *Podolites ternatus?,* SMNH X 1175; Gothemshammar 1, MS 895. ☐ H, I. Internal mould of initial chamber and early juvenile part, ×100, and detail of former, ×1000. Probably young individual of *Odessites lebiensis,* SMNH X 1697; ☐ J. Internal mould of initial chamber and early juvenile part, ×100. Probably young individual of *Odessites lebiensis,* SMNH X 1698. ☐ H-J. Ramsåsa 8, Ra 71-1 KL.

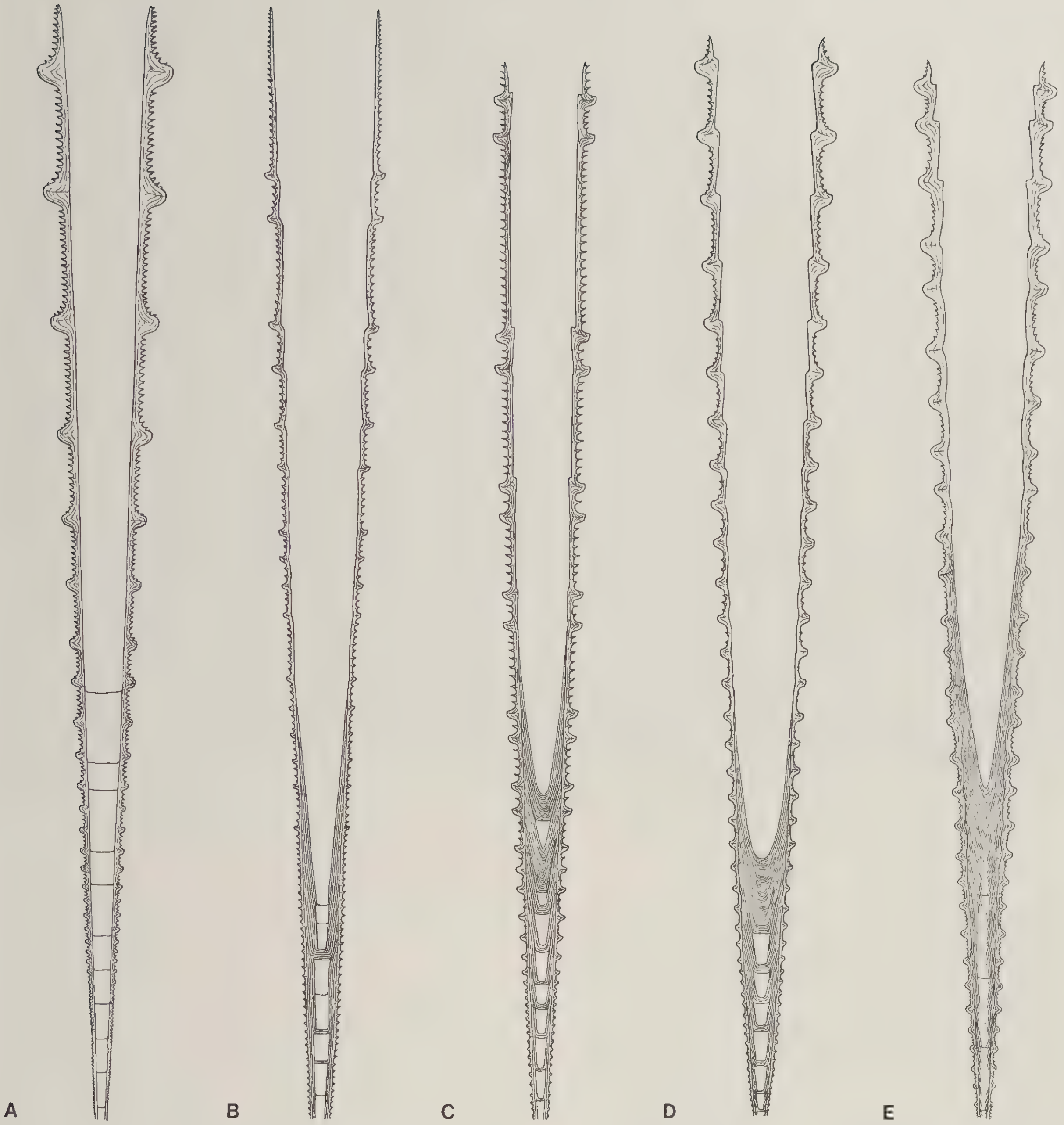


Fig. 12. Schematic longitudinal section to demonstrate different septal arrangements, from free, A, to endoconic, E, septa. ☐ A. *Dicricoconus gutnicus.* ☐ B. *Turmalites slitiensis.* ☐ C. *Lonchidium* n. sp., ☐ D. *Tentaculites hisingeri.* ☐ E. *Tentaculites scalaris.*

The interior of the juvenile part is divided by transverse partitions termed *septa* (sing. septum). These form a series of cones with the apices truncated inserted to some extent into each other. The septa have two principal attitudes: free and well spaced, or lying close together to form structures resembling the endocones of certain nautiloids (Fig. 12). In the descriptions these two main types of septa are called *free* and *endoconic* respectively. The number of septa varies both inter- and intraspecifically. Normally 5–10 septa are developed in adults, but up to 20 septa have been observed in specimens of e.g. *Odessites inflatus* and *Dicricoconus cracens.* There are many more septa when endocones are developed.

The spacing of the free septa is quite variable. In some species it is regular, but in others there is a high variability. The spacing is commonly 0.3 to 0.6 mm, but may be greater or less.

The septa may or may not be symmetrical. Within most species the mode is consistent, although variations in shape may occur (Fig. 39E).

The septum can be divided into two principal parts, the *free part* and the *mural part.* The free part is usually either flat or concave, rarely convex. The latter shape is regarded as anomalous. Generally, the shape of proximal and distal sides of the free part is similar. However, there do occur septa with a flat proximal side and concave distal side (Fig. 60C). Mostly, concave septa are evenly curved, but in some species may be irregular (Fig. 45G). The free part may be perpendicular or oblique to the long axis (Fig. 61F–G).

The mural part of the septum comprises the part in direct contact with the conch wall. It is a direct continuation of the free part and overlaps, partly or entirely, the mural part of the preceding septum. The mural parts are fairly long in most species and taper gradually towards the distal end. In certain species they taper rather rapidly before the next septum (Fig. 60C). The length may differ around the circumference; one side may taper very sharply while the other extends for a considerable length. This feature is particularly well seen in *Tentaculites obstipus* and *T. hisingeri* (Figs. 32D and 28E). Thus, the *suture* forming the contact between the mural part and the conch wall may be straight, oblique or sinuous. However, it is not easily seen because it leaves no imprint on the internal mould of the living chamber.

In many species with free septa those distally commonly have thickened mural parts. (Figs. 12B and 41F). This distal region is called *accretion zone* and corresponds partly to the *Anlagerungszone* of Blind (1969, Fig. 6). Blind noted different development of this zone within a species, relating to the environmental setting in which the tentaculitid dwelled. Thus, thickened septa were interpreted as stabilizing the conch in a vertical position in the substrate with the narrow end downwards (Blind 1969: 135). The greatest thickening characterized specimens living in an arenaceous substrate. The thinnest septa were regarded as typical for specimens living in muddy, quiet environments. Specimens lacking septal thickening, but found with many conchs which had a well developed accretion zone, were interpreted to have dwelled inside empty, vertically standing tentaculitid conchs, even in those of the same species. The empty conchs would, according to Blind, have taken over the anchoring function of the thickened septa (Blind 1969: 135). I cannot believe this explanation and shall return to this topic in a later chapter (p. 53). Blind (1969: 135) rejected phylogenetic significance for the various kinds of septum. In contrast, I consider that the septa are indeed characteristic for certain taxa, especially on a generic or specific level. Thus, the type of septum is constant within a species, even if specimens are found from different environments. As an example, specimens of *Tentaculites hisingeri* are found both on Gotland and in Scania in marls, calcareous mudstones, calcarenites, sandstones, oolites, and always have the same endoconic type of septum. Species of *Dicricoconus* are also found in various environments but always have similar very thin, well spaced septa.

In species with an accretion zone in the septal region, the free parts of the septa are always clearly distinguished. They often maintain more or less the same width along the zone, the diameters may decrease and then increase gradually (Fig. 39E). Generally the total length of the accretion zone is 2.0 to 2.5 mm. Exceptionally, the length may reach 5 mm.

The conjunction of the inner organic layer of the primary shell with the organic layer forming the outermost layer of the septum makes it easy to distinguish the septum from the primary shell. This feature differs in appearance because of the variation in thickness of the organic layers among species. The overlapping mural parts are less distinguishable individually. In species with particularly long mural parts, there is a complete stack of laminae from the first to the last septa formed without intercalated organic layers being apparent (Fig. 50E). Thus the entire stack of mural parts will be seen in section as one lamellar unit.

The outermost laminae of mural parts generally lie parallel to the primary shell wall. Inwards, the undulation reflecting the shape of the conch wall decreases and the mural parts lie subparallel to the long axis of the conch. The wall is commonly entirely smooth before septal development starts, e.g. *Tentaculites obstipus* (Fig. 32D). Mural parts may be markedly oblique to the long axis, i.e. where the septa form endocones. Here, the contact between the primary and secondary shells is clearly discordant.

Endoconic septa appear as a series of thin cones inserted tightly into each other and with the apices directed proximally. The shape of the cones varies even in one specimen. The proximal end may be pointed, rounded, or truncated. Free and mural parts cannot be distinguished. The angle between the sides of the cones and the long axis ranges between 10 and 30°. The angle generally changes from lower in the proximal cones to higher in the distal (Figs. 12D and 32D). The change reflects stronger accretion of lamellae in the proximal part of cones in later formed septa. The endoconic structures may develop along the entire juvenile portion to form a massive body of septa. However, more commonly the more proximal septa are free and the endocones are confined to the distal septa region. Then, the endocones normally occupy a length of 1.5 to 2.0 mm.

A narrow elongate structure through the apices of endocones, is frequently seen. Dewitz (1883: 84–85, Fig. 1c) also interpreted this structure as a canal for soft tissues. Closer examination shows it not to be a canal, but instead a series of very narrow camerae. These are limited proximally and distally by the thin apices of the endocones, and laterally by incompletely developed endocones which lack apices. There is some diffraction in the proximal and distal narrow apices which heightens the impression of a long continuous cavity.

Septal thickness is variable, even within a specimen. Generally, the more proximal septa are thinner, 0.01 to 0.02 mm. The distal septa may be 0.05 to 0.07 mm thick. In many species the last 4 or 5 septa are considerably thicker than those before. There may be alternating thick and thin septa, e.g. *Dicricoconus cracens.*

The mural part, or at least the first portion of it, has the same thickness as the free part. The thickness may change rather rapidly, as in *Seretites? cataractae.* The distal lamellae of the free part generally form the inner laminae of the mural part. Thus, the tapering of the mural part takes place in the inner lamellae. However, this does not apply to strongly thickened septa, where new lamellae are stacked successively only on the mural parts (Figs. 39E and 42D). Such thickening leads to drastic

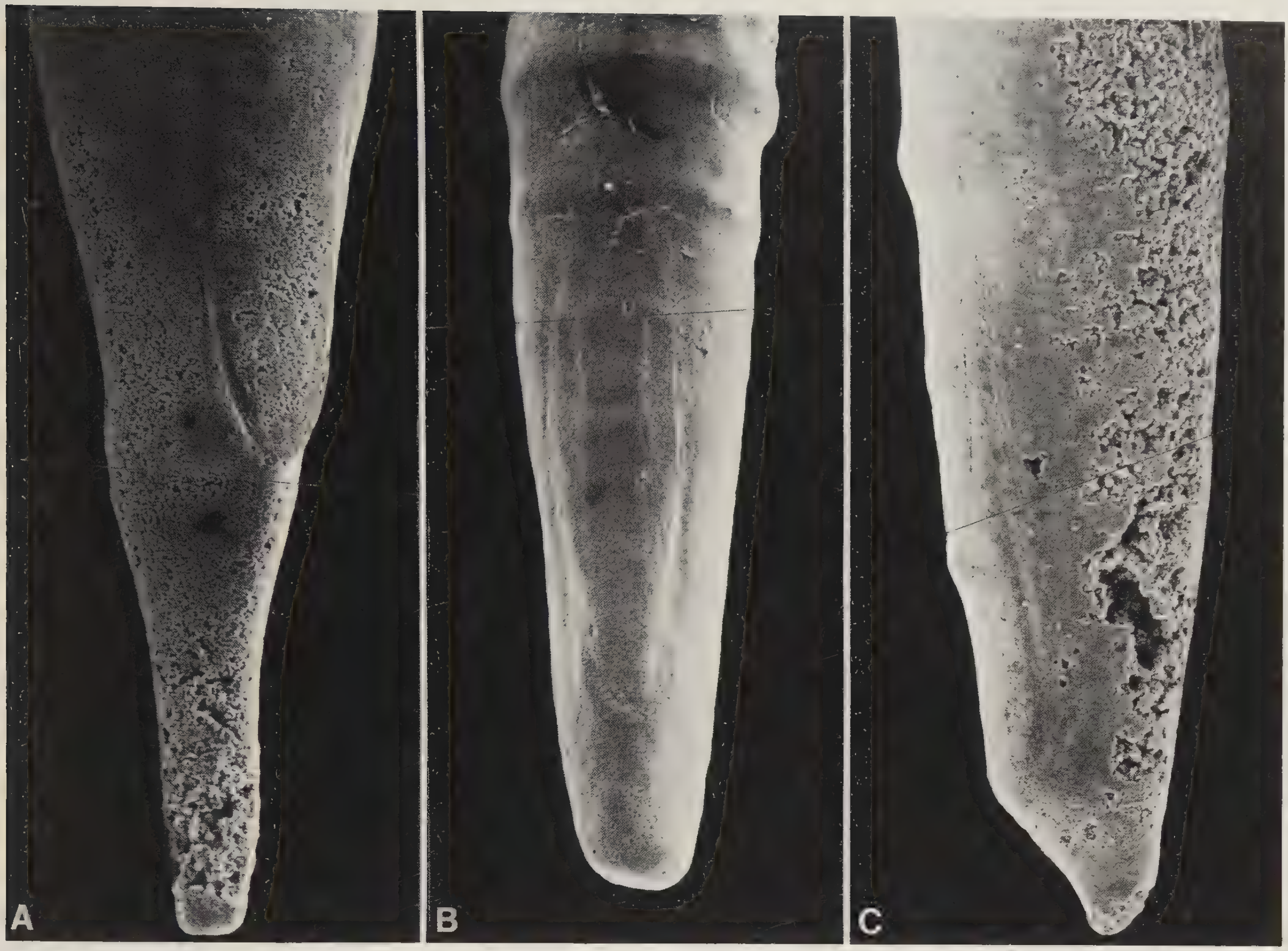


Fig. 13. Internal moulds of living chamber showing symmetrical imprints from the septa. A–C. Ramsåsa 8, Ra 71-1 KL. ☐ A. Probably *Tentaculites scalaris,* SMNH X 1696, × 75. ☐ B. Genus and species indet., SMNH X 1694, × 75. ☐ C. Genus and species indet., SMNH X 1695, × 75.

narrowing of the proximal part of the living chamber into an elongate funnel. This is seen clearly in moulds (Fig. 13A).

In almost all species the last formed septum of adult individuals is most strongly developed. No doubt this relates to its function of support for the soft tissues during the adult stage. It is evident that there were symmetrical oval impressions in the mural parts of septa. These are seen in phosphatized internal moulds of the living chamber of at least two species, including *Tentaculites scalaris* von Schlotheim, in samples from one horizon at Ramsåsa 8, Scania, i.e. the bone-bed of layer *p* (Grönwall & Moberg 1909). Etched samples from this horizon have yielded numerous moulds with a symmetrical, oval platform bounded at its proximal ends by a furrow (Fig. 13). This platform attains its highest relief in its proximal part, while the distal end is more or less continuous with the more distal part of the mould. In well preserved moulds the shallow furrow limiting this zone may be traced. The structure is best seen in fully adult specimens. In juvenile specimens it may be traced, but the platform is poorly developed and only the proximal oval-shaped furrow may be seen (Fig. 13C). Moulds of the initial chamber and the adjacent extreme proximal part do not show similar structures. Thus, these structures developed gradually in size as the adult stage was approached. The surface appears the same inside and outside the oval zone. However, this may be due to the preservation of the moulds, many of which are corroded (cf. Fig. 13A).

The platforms are negative casts of structures on the septa. Hence, they represent symmetrical, oval depressions, deepest in the proximal part and surrounded by a low ridge.

Comparable structures, although with some important differences, have previously been described by Lardeux (1964: 5939; 1969: 11, Fig. 2, Pl. 4: 1–4). On structures in moulds of *Volynites velaini,* the elevated zone at the proximal end is divided into two identical halves by a furrow, and this is lined on each side by a row of minute tubercles which continue far behind the elevated zone. These two features are not present in my material. Otherwise the structures are strikingly alike and it is reasonable to assume that they had a similar function. The differences may be genetic.

In species with free septa, there are cavities between septa. These are called *camerae* (sing. camera). Their shape and size is entirely dependent on the shape and spacing of the septa. Thus, the camerae may be cylindrical or subcylindrical. Cameral shape is remarkably constant even in specimens where the mural parts of the septa are conical, e.g. in *Podolites ternatus* (Fig. 53F). Then the lamellae of the mural parts are truncated. The proximal part of the camera is generally gently rounded but may be rather pointed especially if the septa are strongly conical (Fig. 42D). The distal part of the camera is generally flat or slightly concave.

There is *no* communication between camerae, i.e. the septa are not perforated. This contradicts Blind's (1969: 123–124) statement that such perforations occur and are lined by structures analogous to septal necks in cephalopods. Not one specimen among several hundreds sectioned for this study, nor among more than 600 sectioned conchs studied from other collections has showed either such structures or perforated free parts of the septa.

The wall of the primary shell is uniformly thick. It extends from the embryonic to the adult part. Its thickness is generally between 0.02 and 0.04 mm. The primary shell is normally easily distinguished from the secondary shell because of an intermediate organic layer.

Adult part

The major, distal part of the tentaculitid conch comprises the adult part. Its proximal limit is defined as where the growth angle of the conch changes most rapidly, normally to be lower than in the juvenile part. In some species, e.g. *Podolites paeninsulicola,* the change is not obvious and the same rate of expansion is maintained more or less throughout the conch. In mature specimens the last septum is formed in the region where the growth angle changes. It thus constitutes another character to distinguish the juvenile and adult stages. Many species show a change in ring pattern between the two parts; this will be discussed in a later chapter (p. 50).

The distal limit of the adult part is the open end of the conch, the *aperture.* This term is certainly not confined to adult stages. Its position and size will vary according to the growth stage of the conch. In mature specimens the adult part comprises 70–80% of the total length of the conch.

The adult part is expanding (at 2–4°) or subcylindrical. Both shapes are common.

The interior of the adult part comprises the *living chamber,* i.e. the cavity in which the soft tissues of the tentaculitid animal were supported. The term applies to the distal cavity throughout growth. For much of the ontogeny the living chamber will extend into the proximal part to various amounts depending on the stage of septal development. In the adult, the living chamber will of course be the cavity between the last formed septum and the aperture.

The shape of the living chamber is largely determined by the attitude of the conch wall. Certain elements modify this shape. The shape of the proximal end is determined by the morphology of the last septum. It may or may not be symmetrical with a wide or narrow, pointed, rounded, or obtuse apex. There are all gradations among these shapes. Variation may occur within a specimen because the septal shape changes during ontogeny, e.g. in *Odessites petilus.* Generally, the shape of the last septum is fairly constant within species. This character is occasionally used as diagnostic for species.

The symmetrical impressions which are best developed in the most distal septa, and which lie proximally in the living chamber, are similar in position to the periphract in nautiloid cephalopods. The latter has been demonstrated to function as an area of attachment for retractor muscles, etc. (Mutvei 1957; Teichert 1964: K26–27). It is tempting to infer a similar function for the imprints found in tentaculitids. However, the available material is scanty and confined to a few species from one locality. Therefore, it is of little value to speculate further now on this subject. More finds of well preserved moulds of the living chamber are needed to add to knowledge of the surface structures of the internal wall. Then the relationship between the soft parts and the conch may be better understood.

The smoothness of the wall surface of the proximal part of the living chamber will depend on the length of the mural part of the last septum. The general tendency in all growth stages is for the interior of the rings to be filled by secondary shell deposits (Fig. 56H). In the septal region of many species, the interiors of the rings are filled almost completely to produce a smooth wall surface before secretion of septa (Fig. 32D). However, some specimens, e.g. of *Tentaculites scalaris* von Schlotheim, show the first septal laminae filling the rings (Fig. 33B).

Secondary deposits almost cover the conch, except for the most distal rings. The infill is greatest in the proximal part of the living chamber. It decreases gradually towards the aperture. In some species, e.g. *Tentaculites hisingeri* and *Odessites portensis,* this modification of the internal wall surface occurs slowly. Here, the wall surface becomes more irregular as lamellae are stacked mainly on the inner proximal surfaces of the rings. They produce steeply inclined annular shelves and annular constrictions of the living chamber (Figs. 28D, F and 49E–G).

The amount and rate of infill vary among species. There is some taxonomic value. Species with strongly developed rings which are deeply concave interiorly have a more uneven internal wall surface than species with low rings. The internal wall surface may be smooth, gently undulating, terraced or serrate in section, depending on the inclination and shape of the rings and the amount of infill. Infill with secondary shell deposits and hence internal wall shape varies along the conch.

All these surface structures are easily seen. However, other surface structures are of a very different magnitude. This kind has so far only been seen in one species, but is probably also present in other species. Normally, some verrucosity will be visible on the internal wall surface at a magnitude of × 100 (Fig. 14). At higher magnification, × 500–1000, these microstructures resolve into longitudinal or slightly oblique elements which give the wall surface a slightly plicated appearance (Fig. 14B–C). These riblets are poorly defined, but they seem to lie immediately proximal to, and clearly extend into the interior of, the rings (Fig. 14C). Another less prominent surface structure is formed by irregular, minute, knoblike elevations which cover the whole internal surface. Again the available material is limited and it is not yet known whether these knoblets are comparable to the structures termed *Höckerchen* by Blind (1969, Pl. 13: 3). The latter were demonstrated to form conical terminations of the pseudopuncta. In species with well-developed pseudopuncta, like one *Alternatus*? species from the Mulde Beds, and *Tentaculites scalaris,* these are clearly terminated by small conical tubercles on the annular shelf (Fig. 8C). However, this has so far only been observed in section. It is generally rather difficult to clear matrix from the living chamber to permit a view at large magnification; the matrix tends to be firmly attached to the internal wall surface.

The wall thickness of the primary shell increases slowly towards the distal end. In most species, the thickness ranges between 0.05–0.10 mm. The region closest to the aperture is generally much thinner. This is most conspicuous in conchs where an interspace and a ring have just formed and before the secondary shell has developed (Fig. 55B).

Aperture

The soft tissues of the tentaculitid animal emerged through the open end of the conch. By analogy with other shell-bearing groups this opening is called the *aperture.* The edge of the conch surrounding the aperture is called the *rim.* This edge is always entire and never shows any indentation. The aperture is always circular in undamaged specimens. Some conchs with the aperture preserved show various amounts of compression at the distal end deforming the apertural outline. This is a secondary effect caused by post-depositional compaction. The conch closest to the aperture is most strongly compressed because this is the part where the conch wall is thinnest. The apertural orientation follows the annulation to be perpendicular or oblique to the long axis.

The apertural development depends on the growth stage at death. The aperture may be in a ring-free area (Fig. 45F) or be composed of a ring (Fig. 44F). Several adult specimens have a longer area without rings before the aperture. The area is several times longer than the normal interspaces of the tentaculitid (Fig. 56A). It also has a somewhat thinner wall. Such a development of the conch has been distinguished by some authors as the aperture region (Ljashenko 1959, Fig. 8). However, in some examples it may be seen, that this area is terminated distally by a new ring. Thus it should be regarded merely as a special development of the ring pattern. Besides, an aperture will always be present at any growth stage of the conch and the term should not be confined to the opening in an adult stage.

No operculum has been seen covering the aperture. Therefore, Blind's (1969: 119–121) suggestion that the tentaculitid conch was operculate cannot be corroborated. Blind's hypothesis seems to be based entirely on a

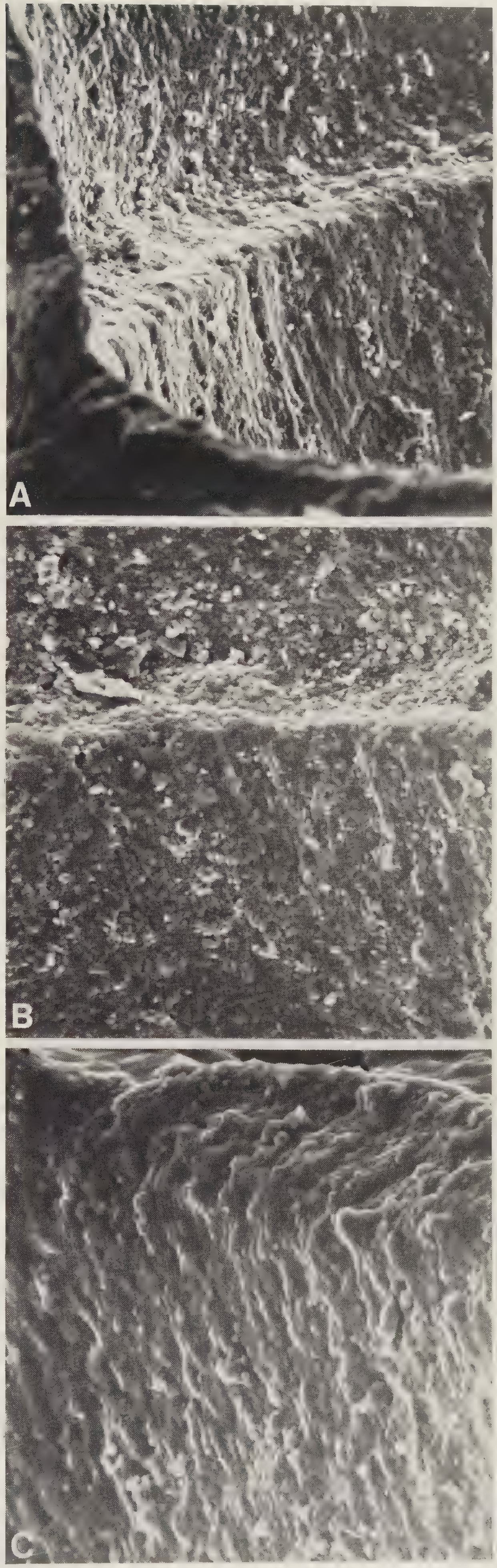


Fig. 14. Oblique apertural view of living chamber in *Podolites ternatus* illustrating longitudinal sculpture on the internal wall surface of the chamber. ☐ A, B ×250. ☐ C ×500. SMNH X 1192; Gothemshammar 1, MS 895.

few thin-sections which show odd shell fragments scattered in the apertures of some conchs (Pl. 14: 3–4, 7). The figures reveal nothing to prove the presence of an operculum. That Blind's figure Pl. 14: 5, reproduced from von Schlotheim (1829; Pl. 29: 9), is a cranidial fragment of *Calymene* sp. has been pointed out by Jaeger (in Schrank 1970: 577). Comparison of the fragment with the tentaculitid conch resting next to it shows immediately that Blind's interpretation is unreasonable; the difference in size of the two shells excludes any connection. Surprisingly, the idea of an operculum in tentaculitoids is maintained by Blind & Stürmer (1977). This interpretation of the small rounded shell fragments on Fig. 5 must still be regarded as mere speculation.

I have examined more than a thousand samples with several tens of thousands of tentaculitid conchs, many in section, yet have found no structures which could be interpreted as opercula. Nor are there any structures which could belong to an opercular apparatus, such as surfaces for the articulation and musculature of the operculum. One cannot entirely exclude that an operculum could have been made of a substance which does not preserve. However, while nothing is known of the morphology of the soft parts it is not constructive to speculate further.

Surface of the conch

The most conspicuous features of the tentaculitid conch are the various surface structures. These are dominated by a transverse *annulation* with rings of different sizes separated by ringless areas of various lengths. Less distinct though visible to the naked eye, is a minute *longitudinal ornamentation* which is present in almost all taxa. The basic surface structures show great variety in development and are highly significant for taxonomy of the tentaculitids.

The annulation is either perpendicular or oblique to the long axis of the conch. The obliquity, which vary from 90° to 60° from the long axis is called the *annular slope* (AS Fig. 4). In most cases the same annular slope is maintained along the full length of the conch, as in *Tentaculites obstipus*. However, there are other species with both types in the same specimen, e.g. in *Tentaculites liquis*.

Two main types of rings can be distinguished on size and construction (Fig. 15). The larger rings, affecting most of the wall structure, are simply called *rings*. The smaller rings, which have a much simpler construction and involve only some laminae, are called *annulets*. The latter lie between the rings and commonly also on their distal slopes. The annulets are fairly homogeneous in size and development, and need not be subdivided. In contrast, the rings exhibit a considerable size range, so for description require further division. The largest rings, easily recognized in most species, are called *primary rings*. They generally delimit cycles of rings which in many taxa are especially typical of the distal conch. The smaller rings are more heterogeneous in size and not easily placed into secondary or tertiary orders of magnitudes. They generally increase gradually in size in a distal direction. This is obvious within each cycle, but of little significance for comparison of adjacent cycles. Thus, these rings are described collectively as *secondary rings*, of a smaller size than the primary rings. In most taxa there is a distinct difference in size, shape and construction between primary and secondary rings. The differences are particularly well seen in the interior of the rings. The distinction of primary and secondary rings applies within species; primary rings in one species may resemble secondary rings of another species.

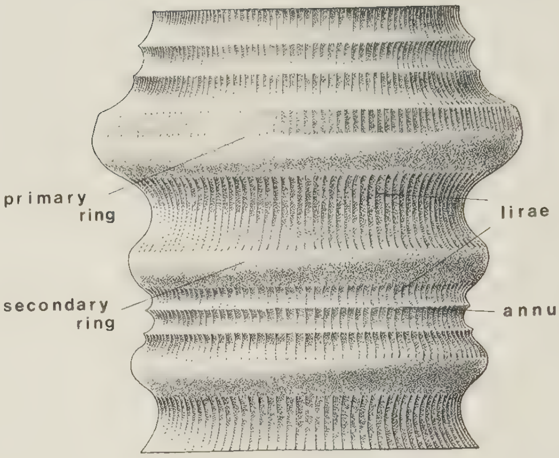


Fig. 15. Schematic figure of exterior of tentaculitid conch to illustrate the terminology for transverse and longitudinal ornament.

Generally, the annulets and rings are easily distinguished by size and construction. However, there are instances when the sizes are very similar and then distinction may be difficult. This applies especially to the extreme juvenile portion in many species. Then, the best designation is just embryonic or juvenile rings. In species with a cyclic ring pattern in which rings increase gradually in size towards the distal end, there may in adults also be rings which are difficult to designate. This is found especially in eroded conchs, because when only the basal part of the annulets is left, they resemble the earliest rings within each cycle. However, the problem may often be resolved by sectioning.

The rings are usually uniform around the circumference. Sometimes, fluctuations occur in width and height. A ring may suddenly become the size of an annulet. This is seen in *Volynites muldiensis*, where the secondary rings immediately before the first primary ring may exhibit such fluctuations (Fig. 56B). Similar fluctuations are seen in rings of *Contractenus* Ljashenko (Ljashenko 1959, Fig. 4d–e; Pl. 14: 1–3).

Rings are generally arranged in a pattern characteristic of the genus and species. The simplest pattern is of gradual increase in size and spacing of rings along the entire conch, as in the genus *Alternatus*?. There are always some fluctuations in ring density, but the basic trend of the ring pattern in maintained.

In the majority of taxa, there is more than one ring pattern per conch: There are generally two, but often three. The proximal part often exhibits one ring pattern, the distal part another. The former may show rings

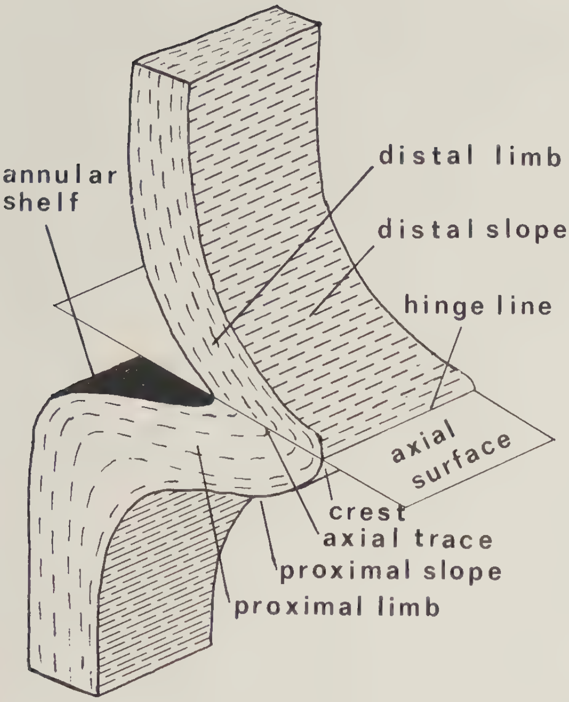


Fig. 16. Schematic section of ring to illustrate the morphological terms for description.

alternating either with ringless portions or with one or more annulets. There is always a gradual distal increase in size and spacing of the rings and in the number of annulets. The distal part usually has its own ring pattern; primary rings may be spaced regularly or irregularly among either secondary rings and annulets or only the latter. A cyclicity for the rings is common. It involves a progressive increase in their number and size per cycle, e.g. in *Podolites ternatus.* In several species, as in *Lonchidium ogmotum* and *L. scanicum,* the two distal rings of each cycle are prominent and give the ring pattern a bi-annulate appearance. Well spaced primary rings alternating only with annulets are typical, of e.g. *Dicricoconus gutnicus* and *Dicricoconus tenuissimus.* A different type of ring pattern, where primary rings and annulets alternate regularly from the proximal juvenile part along the entire conch, is present in for example *Tentaculites hisingeri, Gotlandellites visbyensis* and *G. areolatus.*

Ring arrangement is an important taxonomic character for Silurian genera. This is also well known from Devonian tentaculitoids (e.g., Bouček 1964; Ljashenko 1958, 1969a–c; Lardeux 1969). On species level, the ring patterns, especially the ring density and the cycles, are important but the shape and construction of the rings are more so.

The two basic types of annular ornaments, rings and annulets, vary in attitude, shape and general construction. Their use for taxonomy makes description important. A special terminology is assigned here for these features; some of the terms are already in use, others are introduced. To describe the annulation fully, a section of the conch to reveal the internal structures of the rings and the ringless areas is needed. In conchs with annulation perpendicular to the long axis, cutting sagittally will produce a true cross-section. When the rings are oblique, however, such a section will give a false impression of the ring geometry, which will become more accentuated the higher the obliquity. Thus, before such conchs are sectioned, the specimen must be carefully fixed. Fortunately only a limited number of species examined possess oblique annulation.

For cross-sections, it was found favourable to apply for the various ring structures a terminology which is partly in use by structural geologists for describing folds. This might seem unusual, but it has been convenient and largely appropriate for the ring structures. Structural geologists describe folds as viewed along an imaginary cross-section or perpendicular cut, so the analogy is not remote although there is an immense difference in order of magnitude. However, the three-dimensional picture of the annulation must be kept and all observations must be related to it. The terms described in the following paragraphs are shown in Fig. 16.

The rings form circular folds of the wall, either perpendicular or oblique to the long axis of the conch. Viewed in cross-section this folding involves deflexion of the laminae about an imaginary axis which intersects the plane of section at the point of maximum curvature of each lamina. Theoretically the axis will form the tangent to the point of intersection. The sum of all such points around the ring circumference will be a line of maximum curvature, which would correspond to an axial line in terms of general fold geometry. Here, this line is called *hinge line* or, simply, the *hinge* of the ring. Each ring has two *limbs* which descend from its maximum curvature. The term limb implies the entire wall, while *slope* refers only to the external surface of the limb. The highest point of the ring is its *crest* and the imaginary line connecting all the highest points along the circumference of the ring is called *crestal line.* Commonly, this line will coincide with the hinge line.

The thickness of the ring is increased towards the interior of the conch by the successive addition of laminae. The deflexion of these laminae follows the trend of those outermost, initially with the same curvature but this gradually decreases towards the interior. Through the stacks of folds will pass an imaginary surface which contains all the hinge lines of the individual laminae. This is the *axial surface.* It will cross the circumference and approximately bisect the ring. The axial surface may be planar or curved. Thus, in three-dimensional view it will form a planar disc or a cone, although this is of little practical interest. It is the trace of the plane as seen in cross-section, the *axial trace,* that is of particular value in description of the ring geometry.

Depending upon the relationship of the two limbs of the ring to its axial surface, *symmetrical* or *asymmetrical* rings will be formed. In the former type, the axial surface will everywhere be equidistant from the limits of the two limbs of the ring as defined in any lamina. The axial surface bisects the ring into identical halves and the hinge line coincides with the crestal line. The axial surface is planar and its trace in cross-section will be *orthocline.* An asymmetrical ring is one in which the axial surface is not everywhere equidistant from the limits of the limbs as defined in any lamina. Generally the limbs of such rings dip at different degrees. Frequently the hinge line and the crestal line converge. Depending upon the attitude of the axial surface, its trace will be either *prosocline,* if it is inclined in distal direction, or *ophistocline,* if it is inclined in proximal direction. The trace of the axial surface will seldom be planar but will be either *prosocyrt,* i.e. curve forwards, or *opisthocyrt,* i.e. curve backwards. The strongest curvature of the axial surface is commonly in the outer part of the ring, while it becomes more planar in its inner part. This is well seen in e.g. *Dicricoconus aemulus* and *D. cracens.*

Occasionally, the laminae forming the rings have a hemispheroidal curvature when viewed in section. In such a ring it is impossible to define an axial surface because there is no hinge line. Towards the interior, the curvature generally changes and an axial trace may be distinguished. Such rings are found in e.g. *Odessites inflatus.*

The shape of rings is an important character for identification of tentaculitids. This feature is again best studied in section. In the material examined, the following basic shapes could be distinguished: angular, cuspate, convexo-concave, convexo-plane, and bi-convex. The three latter shapes describe rings as viewed from proximal to distal. The roundness of the crests and the development of the contact between the slopes of each ring, i.e. the hinge line, vary. Commonly, the hinge line is very sharp-edged (Fig. 57C–E), but the contact may also be indistinct and difficult to point out exactly.

The proximal slopes of the rings are almost entirely smooth, while the distal slopes frequently have superimposed annulets and longitudinal elements. In some species these annulets are coarse and may make it rather difficult to define the actual shape of the distal slope of rings. In section such slopes are plicate as in e.g. *Lonchidium ogmotum.* In rings with such annulets, there is often a conspicuous furrow between the crestal line or hinge line of the ring and the first annulet (Fig. 28C). This is called the *crestal furrow.* Often the lirae occupying this furrow emphasize its presence (Fig. 28C).

The interior of the rings was briefly commented upon earlier (p. 38). The concavity produced by the annular flexure of the wall is called *annular concavity.* It forms an annular protrusion of the living chamber. This feature was called *Bucht* by Dewitz (1883, Fig. 2s). The concavities are best developed in the rings closest to the aperture. They generally become modified as the conch grows and new lamellae are added to the rings from the inside of the conch. The annular concavities may or may not be symmetrical; mostly they are asymmetrical. In newly formed rings, the shape of the annular concavity reflects the outer shape of the rings, but rather soon the shape of the concavity changes as lamellae are secreted, chiefly on the interior of the proximal limbs. This thickening inwards of the rings is not caused by a general thickening of one lamella but of a number of short lamellae which are strongly lenticular in cross-section (Figs. 8E and 56H). These lamellae may rest discordantly on one another. The inner surface of the proximal limb attains a characteristic shape in many taxa, the widths and inclinations of lamellae towards the adjacent conch wall varying. The term *annular shelf* is introduced for this surface. This feature was called *Leiste* by Dewitz (1883, Fig. 2v) and *Auflagefläche* by Blind (1969, Fig. 4). The structure is diagnostic in many genera. It also aids in definition of the two basic types of rings. Primary rings always show annular shelves which range from slightly prosocline to opisthocline. The shape of their annular concavities is not the same as the outer shape of the rings, generally shifted distally. The secondary rings have only prosocline annular shelves and the shape of annular concavities more or less reflects the outer shape of the rings. This relates to a much more homogeneous thickness of the wall in these rings. The differences in the interiors of primary and secondary rings is well demonstrated in species of *Lonchidium* (Figs. 37D and 40E).

The terms introduced are also broadly applicable to the description of the annulets. Because these do not develop any continuously folded laminae, it is not possible to describe laminar attitude in terms of the development of the axial surface. However, the wall is generally thin and has only a few, almost parallel laminae, so that some of the terms may be used for the description of their attitude. In some species, e.g. *Lonchidium scanicum,* the outermost parts of the annulets are strongly curved, generally with a prosocyrt attitude.

The area of the conch between two rings is called *interspace.* This term was introduced by Bouček (1964), for analogous structures in dacryoconarid tentaculitoids. Other terms previously used, though inconsistently, are *inter-ring area* (Fisher 1962; Churkin & Carter 1970; Hajłasz 1974), *interannular area* (Sherrard 1967; Blind 1969, *Zwischenringfeld;* Lardeux 1974, *éspace interannulaire;* Hajłasz 1974), *Internodien* (Zagora 1974). Interspaces form between various types of rings and thus will vary in magnitudes. In general three types may be distinguished: *primary* interspaces which lie between primary rings, *secondary* interspaces which lie either between two secondary rings or one primary and one secondary ring. The third and smallest type of interspace will be that between two annulets or one annulet and a ring; it is consequently called a *tertiary* interspace.

The interspaces have concave or flat surfaces viewed in section. The concave interspaces occur mainly between annulets and smaller secondary rings. They form a direct continuation of the slopes of the adjacent rings. In some species, as in *Dicricoconus cracens,* there is also a pronounced concavity in the primary interspaces which gives the characteristic surface structure. In most species the primary interspace is flat. This is particularly evident in species which have widely separated rings. Besides being flat or concave, the interspaces may also lie in different angles to the long axis. In most cases the interspaces are subparallel with or diverge slightly from the long axis. However, there are some species in which the primary interspaces diverge or converge strongly. The former type viewed in section, resembles a series of incomplete cones inserted into one another. This is typical of interspaces in the genus *Multiconus.* It is not a very common development of the interspaces in the material studied, and it always occurs in the early parts of the conchs where the growth angle is largest. Strongly convergent interspaces are common in some species described here, e.g. *Tractabilopsis serratus* and *Volynites scalpratus.* In these species, the inclination is 7–12° towards the long axis, generally increasing distally. In *Tractabilopsis serratus* a slightly convex outline of the proximal parts of the interspaces emphasizes the convergent attitude.

Interspaces exhibit various types of transverse ornament. The primary interspaces have secondary rings and/or annulets, the secondary interspaces have only annulets. The tertiary interspaces lack rings. Instead, in many species, they show longitudinal riblets.

An ornament hitherto much neglected is the minute longitudinal riblets along the conch. They occur in most species and differ in size and density. For this type of ornament the term *lirae* is introduced. They are defined as longitudinal fine parallel ridges on the surface of the conch, of a magnitude such that they are not easily observed with the naked eye. The term and its definition are essentially the same as used in cephalopods for both transverse and longitudinal minute sculptural elements. Longitudinal sculptural elements are common in dacryoconarid tentaculitoids, but are of much greater size and easily seen without any optical equipment. For those structures the term *rib,* as used by Bouček (1964), is suitable.

Lirae have been little treated previously. The few papers dealing with these structures have used the term *striae* to designate the longitudinal elements. Ljashenko (1959) used the terms *longitudinal furrows and wrinkles,* Sherrard (1967) *longitudinal striation,* Blind (1969) *Längsstreifen,* Churkin & Carter (1970) *longitudinal striae,* and Hajłasz (1974) described the elements as *longitudinal furrows or striations.* The terms striae and striation refer to the direct opposite of lirae: striae are small grooves, while the lirae are minute raised ribs separated by wide smooth areas (Fig. 17). Only Lardeux (1969) recognized these sculptural elements correctly and used the term *microcostule* for designating them.

Lirae occur in almost all species examined. The only exceptions are the two species of *Gotlandellites,* which seem entirely to lack this feature. The lirae extend wholly along and around the conch. They cover the tertiary interspaces and cross the crests of the annulets (Fig. 17A). However, they rarely extend over the rings. Generally there is a clear break in development of the lirae from immediately before the proximal slope of a ring to just after the crest. Only a few species, e.g. *Dicricoconus svarvariensis,* have lirae on the crests and proximal slopes of the primary rings (Fig. 63A).

The lirae are commonly well developed on the distal slopes of the rings. They are always perpendicular to the rings, even in species with oblique rings. The density of the lirae changes gradually during ontogeny. They are more dense in the proximal than in the distal part. It is rather difficult to follow an individual lira because it becomes interrupted by rings, but it seems likely that it should be quite persistent. Thus, the decreasing density of the lirae probably reflects merely the expansion of the conch, and not disappearance of lirae. Density is commonly 5–10 per 0.1 mm width. The spaces between lirae are generally 3–4 times the width of a lira. They are flat and smooth, and irregularities have only occasionally been observed. In *Dicricoconus clintianus* some very minute striations occur (Fig. 17E), but their nature remains obscure because the observations are so far very few.

The construction of the lirae is not known satisfactorily in detail. It proved difficult to make transverse sections of the lirae for SEM studies. Because of their minute size they generally become diffuse when the polished surface is etched before coating with gold. However, the few incomplete sections made so far suggest that the lirae formed by outward folding of the outermost lamellae of the conch, and consequently at the earliest stage of shell formation.

Pathology, malformation and regeneration of the conch

A striking feature of the tentaculitids studied is the great ability to repair damage to the conch by the generation of new shell. Repairs of injured conchs are very common in almost every species. Among certain populations regenerated conchs are especially abundant, e.g. in the muddy environments of the Mulde and Eke Beds. Here, part or all of the conch has been fractured to leave jagged margins and then has been repaired by secretion of new shell substance. Sometimes there are several attempts at repair before normal growth resumes (Fig. 18C). The attempts were obviously interrupted by new fracturing of the conch. The healed injuries range from minute round spots about 0.1 mm in diameter to damage which suggests fracturing of the conch around its full circumference.

The new shell repairing damage is always secreted from the inside of the conch. It starts well below the margin of the fracture (Fig. 19B, D) obviously to enlarge the surface of contact against the old conch. The repaired part always attains the same diameter as the original conch. Sometimes regeneration involves completely new construction of rings well below the fractured margin of the old shell and direct contact is not established between the broken and regenerated shell.

The regenerated rings are initially very distorted, and differences from normal in attitude, size and density of the rings generally continue for some length. However, annulation characterizing the species is soon resumed (Fig. 18C–E). The first lirae of the regenerated shell are also very irregular and diffuse and only gradually resume their normal development (Fig. 18C). The regeneration of the shell nearly always follows the same long axis as the original conch. Thus, conchs geniculated as a result of regeneration are rare.

The cause of injuries to the conch can only be speculated upon. It is tempting to point to predation as a cause, but other mechanisms could as well have been responsible, e.g. fracturing by sudden strong currents or waves. The smaller round damages to some superficial extent

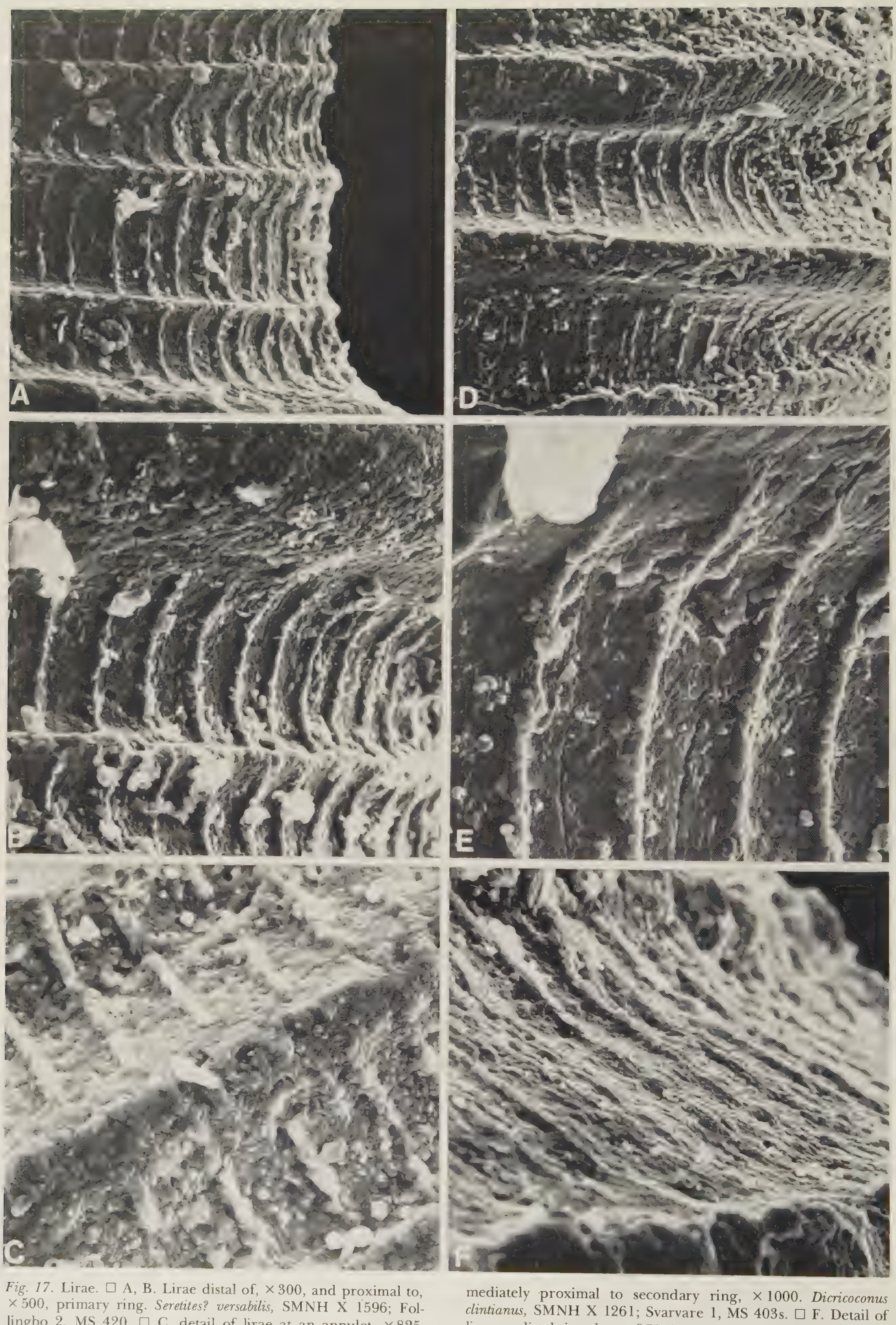


Fig. 17. Lirae. □ A, B. Lirae distal of, ×300, and proximal to, ×500, primary ring. *Seretites? versabilis,* SMNH X 1596; Follingbo 2, MS 420. □ C, detail of lirae at an annulet, ×825. *Odessites lauensis,* SMNH X 1405; Lau Backar 1, MS 456. □ D, E. Lirae in secondary interspaces, ×250, and detail of lirae immediately proximal to secondary ring, ×1000. *Dicricoconus clintianus,* SMNH X 1261; Svarvare 1, MS 403s. □ F. Detail of lirae on distal ring slope of *Dicricoconus svarvariensis,* ×750. Note the bifurcation of zone lirae. SMNH X 1604; Svarvare 1, G 75-3 MB.

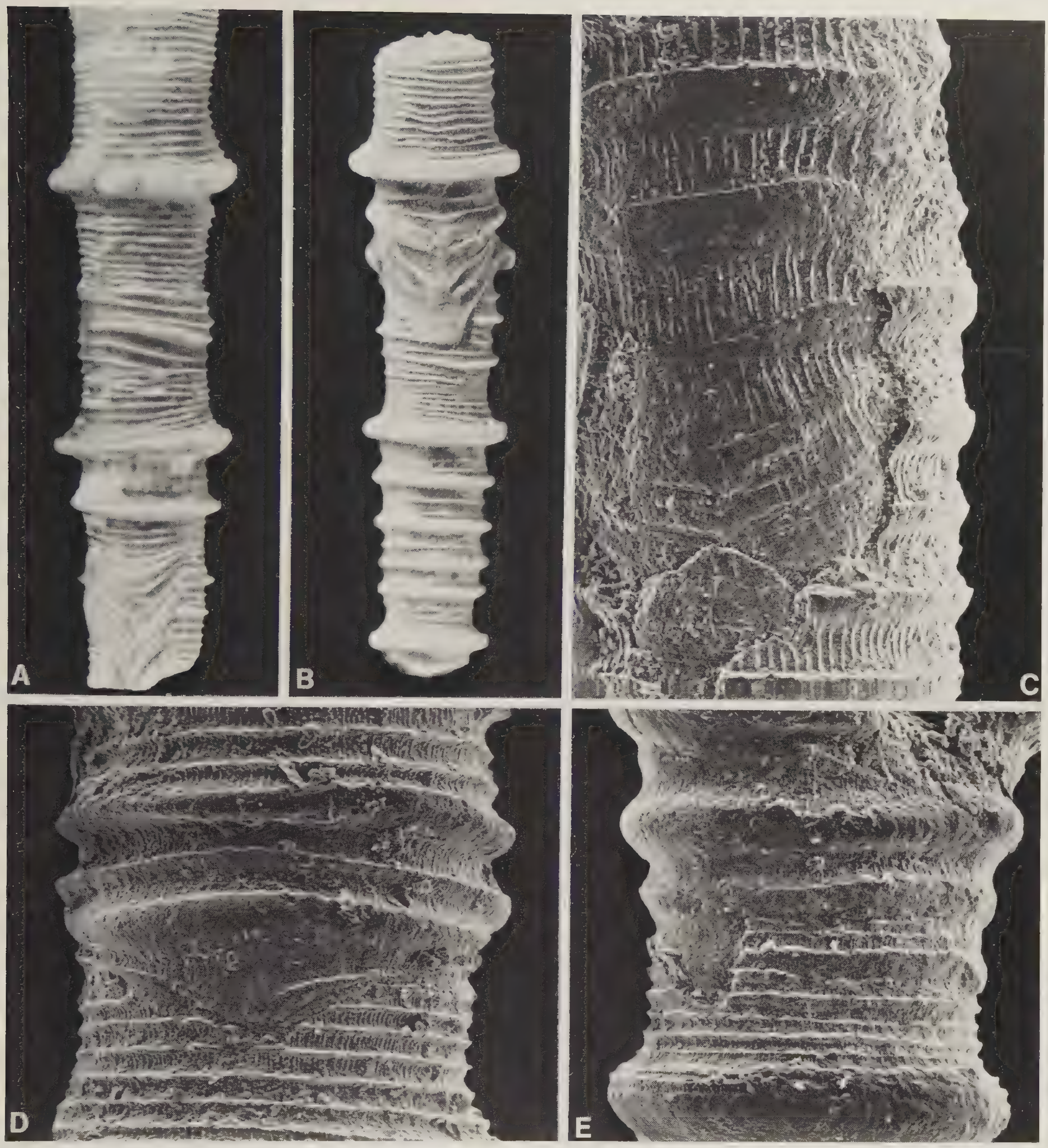


Fig. 18. Malformations and repairs to conchs. ☐ A. *Volynites muldiensis,* SMNH X 1673, ×25. ☐ B. Same species as A, SMNH X 1674, ×25. A, B: Mulde Tegelbruk 1, MS 10/1960: x. ☐ C. *Seretites? versabilis,* SMNH X 1693, ×75; Follingbo 2, MS 420. ☐ D. *Odessites majstriensis,* SMNH X 1572, ×75; Kättelviken 4, MS 778. ☐ E. *Lonchidium extensum,* SMNH X 1552, ×75; Bankvät 1, MS 877.

resemble holes produced by, e.g., scavenging gastropods.

Another type of malformation found commonly, and where the causes are perhaps more obvious, are distortions in growth, mainly displayed as irregularities in the formation of the rings. The latter have been proved by Blind (1970) to be caused by epizoans on the conch. Various epizoans, e.g. "cornulitids" and bryozoans, by settling on the conch close to the aperture, disturbed the shell-generating epithelium in such a way that deflexions from the normal course of the rings occurred. It is obvious that shell generation partly ceased for some time as a result of the epizoans.

Irregularities caused by epizoans are common in almost every population studied on Gotland, but are very rare in Scania. Often no epizoans remain on the conchs, but epizoans found *in situ* show convincingly their disturbing effects (Fig. 20D). There is a marked increase in the frequency of distorted conchs when there are more epizoans. This can be easily observed in samples from, e.g., marly horizons in the Mulde and Eke Beds, which

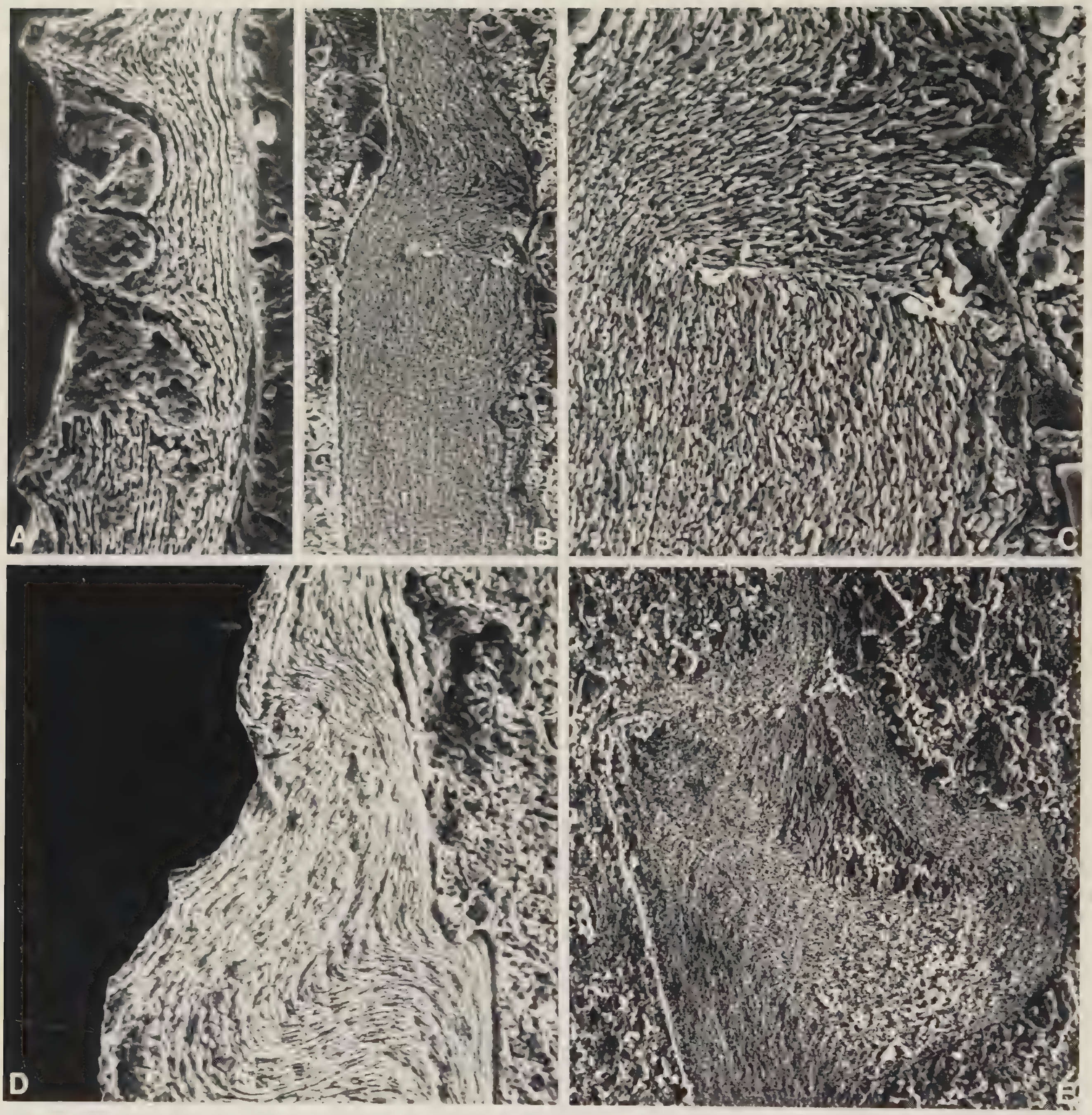


Fig. 19. Longitudinal sections of conchs showing repairs to conch wall. ☐ A. *Volynites muldiensis,* SMNH X 1222, ×200; Mulde Tegelbruk 1, MS 10/1961: x. ☐ B, C. *Lonchidium mobergi,* ×300 and ×900, SMNH X 1621; Ramsåsa 2, Ra 71-3 KL. ☐ D. *Volynites muldiensis,* SMNH X 1226, ×350; Mulde Tegelbruk 1, MS 10/1961: 1. ☐ E. *Tractabilopsis serratus,* SMNH X 1122, ×200; Haganäs 1, MS 489.

yield very diverse faunas of "cornulitids" and coiled serpulids. It is striking that in Scania, where these two groups of epizoans occur only sparsely distortions of the tentaculitid conchs are rare.

The mutual relationship between tentaculitids and epizoan organisms is a challenging topic for detailed study. Important information on the mode of life of tentaculitids and, perhaps, on their zoological affinity might be expected to be obtained. Blind (1970) considered the positive phototropic growth of epizoans on tentaculitids as support for his theory (1969) of an upright living position for tentaculitids with the apex anchored in the bottom sediment. The present study to some extent corroborates Blind's (1970) results on the living attitude. However, investigation has been very limited and can only be regarded as a pilot study for a forthcoming more extensive study of epizoans vs. tentaculitids.

From the locality of Mulde Tegelbruk 1, located in the Mulde Beds, all tentaculitids with epizoans *in situ* were picked and counted. From a total number of about 4800 conchs of three species, 150 conchs or 3.1% of the total number had epizoans. The proportion of conchs with disturbed growth was much higher, however. Of these

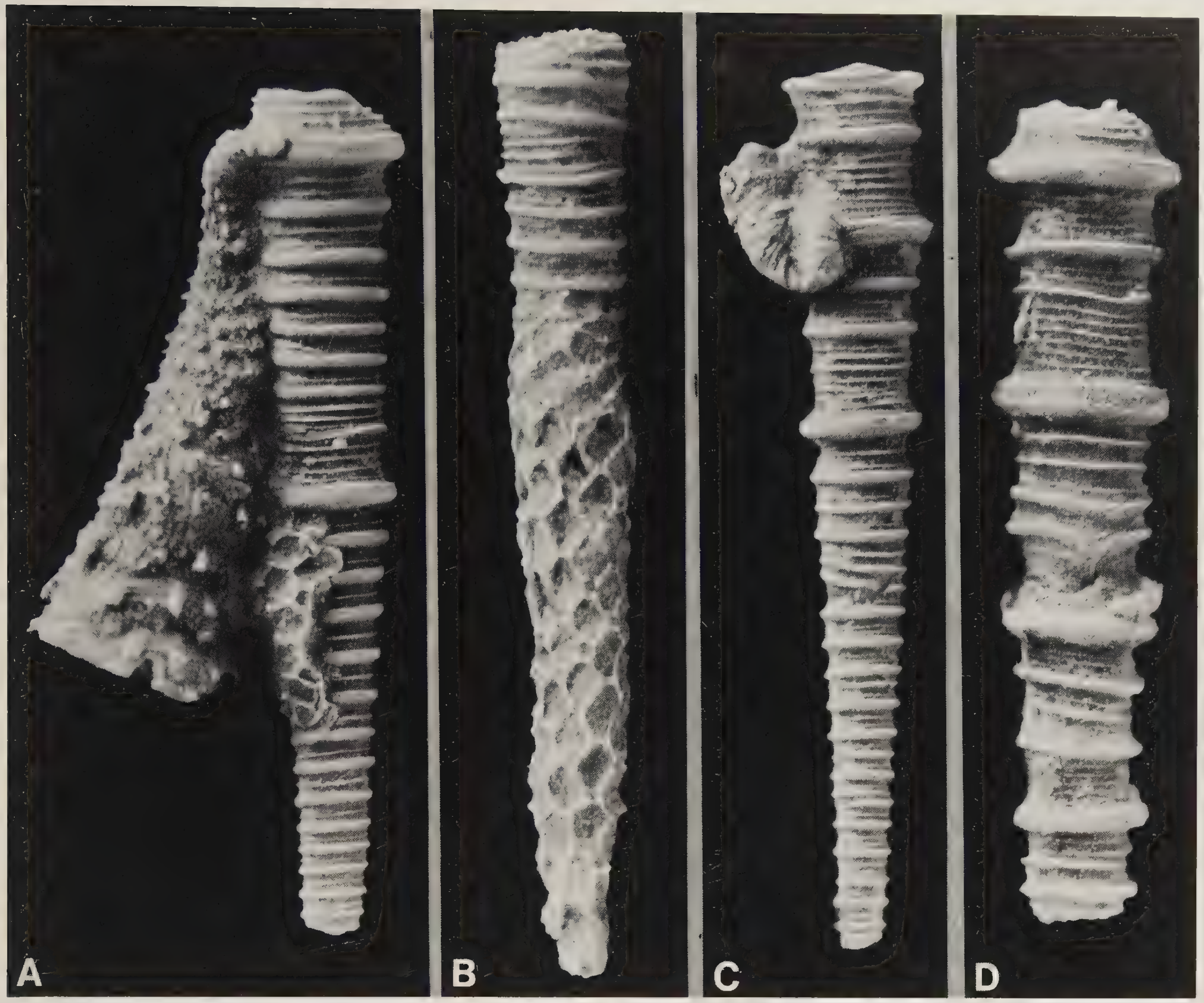


Fig. 20. Epizoans on *Volynites muldiensis.* A–D. Mulde Tegelbruk 1, MS 10/1961: coll. ☐ A. Bryozoan and "cornulitid", ×25; SMNH X 1672. ☐ B. Bryozoan completely covering juvenile conch, ×25. SMNH X 1678. ☐ C. *Conchicolites* sp., ×25. Note the change in its direction of growth. SMNH X 1677. ☐ D. Larval "cornulitid" attached to distal slope of primary ring, ×25. Note disturbance of the growth pattern of the tentaculitid. SMNH X 1676.

150 conchs the majority, or 140 conchs, showed different "cornulitid" epizoans, while attached bryozoans were confined to the other 10 conchs. The larval part of the "cornulitid" is generally parallel to the rings of the tentaculitid and very often rests on the distal slope of a ring. This mode of attachment is particularly common in the distal part of the conch. Proximally, the larval parts are more randomly oriented. There is a difference in the direction of the wider end of proximally and distally placed "cornulitids". In the distal part of the tentaculitid conch the majority of "cornulitids" have their wider end directed towards the aperture of the tentaculitid. In the proximal part there are also many tubes with apertures directed towards the apex of the tentaculitid. In such "cornulitids" the main proportion have the wider end curving gradually upwards from the tentaculitid conch, so that only the proximal part is attached to the tentaculitid conch (Fig. 20A). The overall orientation for the "cornulitids" examined was determined, and 75 conchs or 53.6 % of the total number had the wider end directed towards the aperture of the tentaculitid conch, while 44 conchs (31.4 %) had the opposite direction. The remaining 21 conchs (15 %) could not be referred to a group because only the larval parts remained. From this simple study the following results may be tentatively established.

The majority of the conchs with "cornulitids" *in situ* show tubes of the latter arranged with the larval part parallel to the rings and preferably on their distal slopes and with the wider end directed towards the aperture of the tentaculitid. Where there are several of these "cornulitids" on the same tentaculitid, they occur around the entire circumference of the conch, and are mainly confined to the adult part. In contrast, "cornulitid" tubes arranged with the wider end towards the apex of the tentaculitid commonly have their aperture directed at almost 90° to the tentaculitid conch. Their larval parts are more randomly oriented. When several such "cornulitids" occur on one tentaculitid conch, there is generally a preference for one side of the conch.

Bryozoans found *in situ* on the tentaculitid conchs also show two principal modes of attachment. In one, the

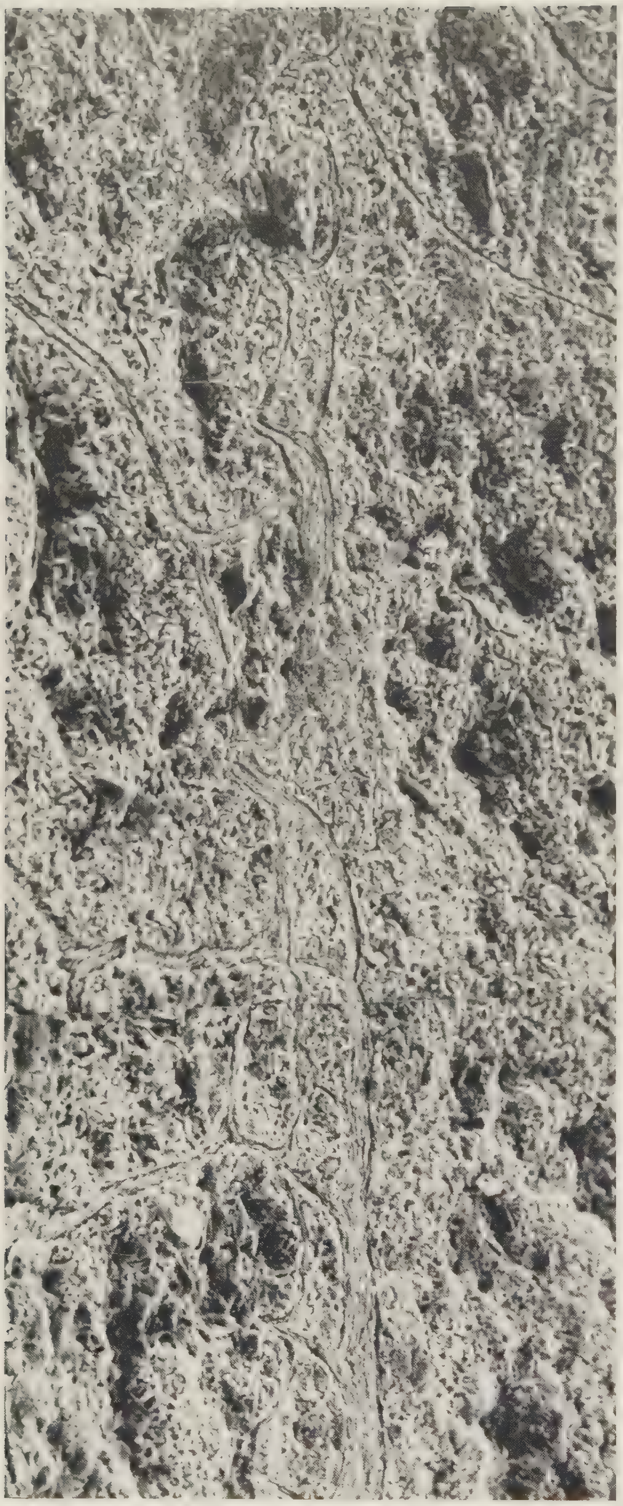


Fig. 21. Longitudinal section of epizoic bryozoan on *Volynites muldiensis,* ×260. Note the extremely thin conch wall of the tentaculitid. SMNH X 1223; Mulde Tegelbruk 1, MS 10/1961: coll.

bryozoan zooecia occur around the entire conch, close to the aperture and sometimes completely surrounding it. Such conchs also have a thinner wall (Fig. 21). The other mode is limited patchy attachment on only one side of the tentaculitid conch. The zooecia may be more proximal and are not confined to the adult part of the tentaculitid.

The principal locations of epizoans may be tentatively interpreted to show two modes of epizoan attachment. One implies attachment on the conch while the tentaculitid was alive, the other mode suggests post-mortem attachment. On living tentaculitids, the "cornulitids" favoured a position where their apertures were directed towards the tentaculitid aperture, and bryozoans also took advantage of being close to its aperture. One may speculate at length on the possible relationship between host and epizoans, but the fact that epizoans caused distortions in the formation of its conch shows that frequently this relationship was harmful to the tentaculitid. If the "cornulitid" animal were a suspension-feeder, which seems plausible, one may suggest that the tentaculitid animal during some stage of its adult life had a vertical mode of life with the aperture directed upwards. This supports Blind's (1969, 1970) hypothesis. Whether a permanently sessile life or a partly free-living habitat was involved is difficult to assess from the present study. However, the model has objections, especially if account is taken of the morphology of certain "cornulitids". Several of the "cornulitid" tubes attached near the aperture of the tentaculitid are voluminous with thick, wide conchs, and often larger in size than the tentaculitid host (Fig. 20A). The tentaculitid would probably have had difficulty supporting such an eaizoan while still maintaining a vertical position, unless it could compensate for the imbalance. There are no morphological elements known which suggests such an ability in the tentaculitid. The large "cornulitid" conchs are always restricted to one per tentaculitid conch, so the possibility of post-mortem attachment remains.

Observation of some sectioned conchs suggests that tentaculitids possessed the ability to encapsulate foreign particles which entered the living chamber (Figs. 22 and 53G; Blind 1969, Pl. 12: 1). However, the phenomenon is rare. In one conch of *Podolites paeninsulicola* several particles have been encapsulated at different positions between the primary shell and the mural parts of the septa (Fig. 22). It is notable that this encapsulement has resulted in a partial thickening of the mural parts. Thus, there are no signs of accretion of laminae to the particles in a pearl-like fashion, but the foreign particles have just been encysted.

Ontogeny and functional morphology

The ontogeny of tentaculitids has been treated in some detail by Lardeux (1969) and Blind (1969). The latter author gives a lengthy account particularly of the development of the embryonic stage and draws comparisons with the embryonic development of some recent cephalopods and gastropods. Many of Blind's conclusions seem too far-reaching, especially his postulates of trochophore and veliger stages for the early growth phases of tentaculitids.

Blind (1969: 108) pointed out that initial chambers are rarely found, especially those still attached to the juvenile part of the conch. This was corroborated by the present study. Thus, it is difficult in certain taxa to study the very early development of the tentaculitid conch. Blind (1969: 44) refers all but two of his illustrations to the genus *Tentaculites* and claims that his account of the ontogeny is based on this genus (Blind 1969: 126). It is obvious from his illustrations that only one figure shows a representative of *Tentaculites,* i.e. Pl. 17: 3 which is denoted as *Volynites* sp.! I regard it impossible to refer the initial chamber figured in Pl. 11: 1 to genus because most genera except those of the family Volynitidae have initial chambers like that figured. Thus, the description of very early ontogenetic development can only be given broadly until exactly what the initial chamber of each genus looks like is known.

From the present study I agree with Blind (1969: 128) that the growth of the tentaculitid conch is characterized by three major phases of development, i.e. embryonic, juvenile and adult stages. This is reflected in the threefold division of the conch. The same three growth stages were recognized by Lardeux (1969) who described the basic principles of growth and gave illustrations using one representative of the family Uniconidae (Lardeux 1969, Fig. 148). How the growth stages should be differentiated biologically can as yet only be speculated upon. Blind (1969: 127) assumes the three growth stages correspond to phases of metamorphosis. This is plausible. However, I think it is enough so far to demonstrate from the morphology of the conch that there are three well differentiated growth stages.

The first hard tissue formed is the initial chamber. It may either be conical and passing directly into the juvenile part, or slightly drop-shaped with a weak constriction distally, e.g. as in the genus *Podolites.* Some initial chambers show signs of a minute elongate tip forming the apex (Figs. 11E–F). The cross-sectional shape of the initial chamber shows a weak bilateral symmetry, which is soon lost as the external shape in section becomes completely circular, and thus radially symmetrical. Internally, the bilateral symmetry is retained, however. The initial chamber and the earliest juvenile part is commonly curved, sometimes to a considerable extent (Fig. 52E). In some species the initial chamber lies at a marked angle to the juvenile part (Fig. 11J), but this seems exceptional. The most proximal juvenile portion commonly expands at a very low angle, and it may become subcylindrical in shape.

The first rings, i.e. those on the initial chamber, always lie oblique to the long axis but they rapidly become perpendicular to this axis in the early juvenile stage. This development of the first rings was also shown by Lardeux (1969, Figs. 148b–c).

Juvenile growth is characterized by the formation of rings which are generally regular in size and spacing, and which increase gradually distally. The juvenile conch expands significantly. In most species the growth angle differs markedly from that during the subsequent, adult growth stage. The juvenile rate of expansion also differs considerably from that of the transition zone towards the initial chamber. The juvenile conch is thin and is composed of few laminae. A thin wall is formed through the juvenile growth stage and in part of the adult growth stage until the first septum develops and the wall becomes strengthened accordingly. Lardeux's (1969: 187) statement that the first septum is developed "a considerable time" after the early adult growth stage has been reached is corroborated by many observations here. Septa never occur in conchs sectioned until after several rings have developed and the growth angle has changed, which is after several millimetres. Blind (1969: 127) characterized the juvenile part as having a thin wall and thin septa, and therefore assumed formation of the first septum during the juvenile growth stage. Late development of septa makes it easy to determine, even in fractured material, whether the tentaculitid was juvenile or adult at death.

The transition to the adult growth stage involves several drastic changes in the growth pattern. The growth

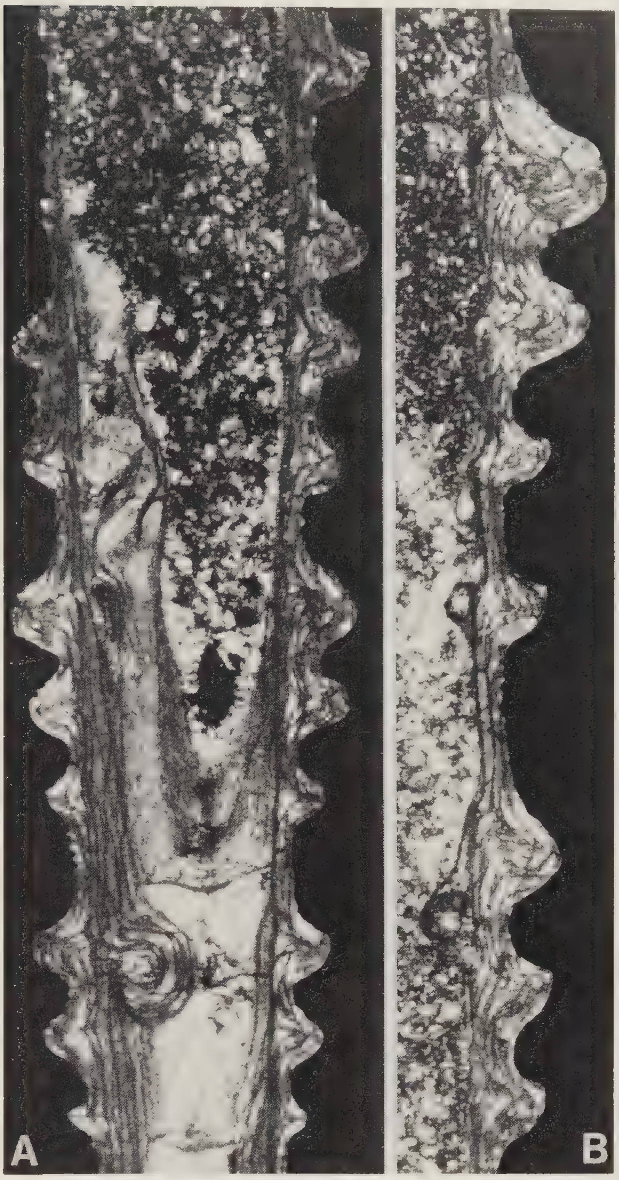


Fig. 22. Specimen showing inclusions of foreign bodies. □ A. In the septal region, × 50, and □ B, in the distal conch. *Podolites paeninsulicola,* SGU type collection; Ängmans 1, unnumbered SGU sample (coll. J. E. Hede).

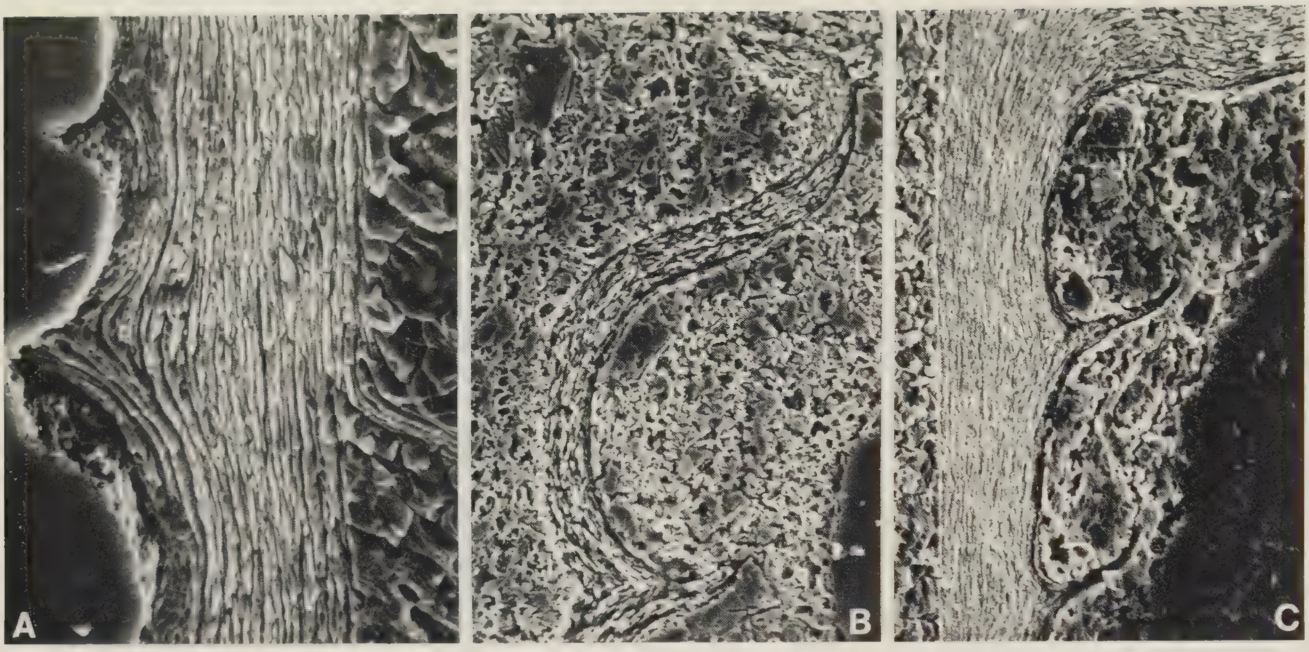


Fig. 23. Longitudinal sections of conch wall illustrating the laminar arrangement in rings and annulets. ☐ A. Juvenile ring of *Volynites muldiensis,* SMNH X 1219, ×700; Mulde Tegelbruk 1, MS 798. ☐ B. Adult primary ring and annulet of *Odessites portensis,* SMNH X 1688, ×250; Klinta 4, Kl 67-32 LJ. ☐ C. Distal annulets of *Odessites lauensis,* SMNH X 1409, ×250; Lau Backar 1, MS 51.

angle decreases, the rings change in attitude and arrangement, and the first septa form in the most proximal part of the conch. A new element of the microstructure of the conch wall is the formation of pseudopuncta. However, this feature is not always distinct, and is missing entirely in several taxa. The many changes in morphology at this level made Blind (1969: 126) postulate a new life habit for the tentaculitid. The general development of the initial chamber and the thin-walled juvenile part without septa were taken as evidence of a free mode of life. The commencement of an adult stage was considered to coincide with the change to a sessile mode of life with the narrow, proximal part inserted into the sediment and the aperture directed upwards. The septa were regarded as structure to stabilize the animal in this new position. Blind (1969: 127) went further to suggest that some individuals utilised empty, vertical conchs as dwelling tubes and continued their development in these with a septal arrangement much reduced compared to ordinary specimens. That this suggestion is highly speculative and improbable will be discussed in a later chapter (p. 53) on ecology of tentaculitids.

The pattern of adult growth shows the mechanism of formation of the conch. It is obvious from many specimens sectioned, particularly those studied with SEM techniques, that the tentaculitid conch is an exoskeleton formed by a shell-secreting tissue. Successive lamellae are added inwards. Thus, the very first lamina produced forms the outermost protective layer separating the soft tissues from the surrounding environment. It is normal to assume shell generation was from mantle-like tissue as, e.g., in molluscs and brachiopods (e.g. Fisher 1962: w103). Contrasting opinions have been published too; e.g. Bouček (1964: 29) suggested outward accretion of the laminae, and Yoder & Erdtmann (1975) regarded the conch as a functional endoskeleton produced by a mantle.

In the juvenile part, where the primary shell is thin, it is often difficult to make detailed examination of the construction. In the adult part such observations are much easier. The primary shell is secreted in sets of laminae. These are added, imbricating, with short surfaces of contact between sets. Thus, the construction may be compared to a series of cones inserted slightly into one another. Certainly the short contacts betwen laminae constitute points of weakness. Very soon after formation of the outermost laminae new sets of laminae are secreted towards the inside of the conch and thus strengthen the joints. It is interesting that, where the conch wall is partially destroyed, the regenerated laminae healing the wound are added far below the margin of the fracture, when they create a larger contact surface.

The contacts between laminae are fundamentally different in rings and annulets. The latter form by outward deflexion of the outermost laminae then subsequent additions at some distance from their margin (Fig. 23B–C). The internal wall surface at an annulet will be more or less parallel to the long axis. In rings, the laminae forming the distal limb are attached close to the margin of the laminae forming the preceding proximal limb (Fig. 23B). New laminae are added successively inwards, the annular concavities become filled gradually and the internal wall becomes smooth.

Mineral secretion alternates with the formation of organic layers. Before secondary shell is formed, a particularly thick internal organic layer lining the entire living chamber is secreted. This layer varies considerably in development among taxa. The alternation of calcitic laminae and organic layers was interpreted by Blind

(1969: 128) to result from addition during periods of greater and lesser growth respectively. This may be correct but deposition as e.g., in brachiopods (cf. Williams 1968: 2–3, Fig. 1) should also be considered. Blind's theory is supported by the occurrence of the laminae as successive packages of lamellae and also because many species exhibit pronouncedly rhythmical ring patterns. With such ring patterns, the majority of specimens show complete ring cycles and rings are completely formed, never only partly developed. Thus the cycles seem to form comparatively rapidly.

As growth proceeds, the laminae tend to become more parallel to the long axis of the conch. Formation of secondary shell in the adult part varies among genera and the shapes attained have some taxonomic significance. The most completely filled annular concavities occur in the genus *Dicricoconus* where the living chamber has an almost smooth internal wall surface. There is a general tendency in most taxa to smooth the irregular internal wall surface of the living chamber. The smoothest parts are found in the proximal part of the chamber, while the wall surface becomes gradually rougher towards the distal end. Proximally the mural part of the last septum is largely responsible for the smoothing.

The gradual smoothing of the living chamber towards the aperture probably had functional importance. If the rings functioned as attachment surfaces for the soft tissues, as suggested by Blind (1969: 128), it is likely that this function became lost gradually in the most proximal rings as the soft parts grew and expanded distally and new rings formed to serve as surfaces of attachment. If the tentaculitid animal possessed the ability to move soft tissues out through the aperture, it should have been advantageous to have a smooth internal wall surface in the part of the living chamber where the soft parts were not attached, for retraction back into the protective conch. An unfilled annular cavity would impede such retraction. The function of the rings as attachment surfaces is plausible also for the following reason. As the adult growth stage commenced, there was initiated a buckling of the crystal tablets of the conch wall into tubercles. The tubercles stacked, form pseudopuncta. They are particularly well developed internally on the proximal limbs of rings, i.e. on the annular shelves. The tubercles are most fully developed in the outermost laminae of annular shelves. However, as the conch grows and new lamellae are added onto the shelves, the tubercles diminish and finally disappear completely (Fig. 8B). This could be interpreted as an adaptation for frictionless movement distally of the soft parts, with the consequent decrease in importance of tubercles for enlarging the surface area of annular shelves. There are other structures in the rings which could have served for attachment of soft parts, i.e. the longitudinal, slightly oblique, minute ribs of some conchs. Observations of such ribs are still very limited, however, and their interpretation must await examination of further examples. More extensive study of the inside of the living chamber could help reconstruct and interpret the nature of the soft tissues.

It has long been suggested that tentaculitids had a tentacular apparatus, more recently in Blind (1969: 128) and Blind & Stürmer (1977). It should be stressed that the name of the group is unrelated to possession of such an apparatus. The name was given when tentaculitoids were regarded as parts of the crinoid crown (von Schlotheim 1820). Brassel *et al.* (1971, Pls. 1–2) showed two X-ray photographs of a Devonian dacryoconarid which they assumed might have a tentacular apparatus emerging from the distal end of the conch. Later, Blind & Stürmer (1977, Figs. 1–4) illustrated similar structures from the same species, *Viriatellina fuchsi* (Kutscher). Judging from the prints, without having been able to examine the original X-ray photographs, it is difficult to evaluate the Blind & Stürmer interpretation. One must keep in mind the basic differences in life habit between tentaculitids and dacryoconarids when transfering interpretation of a possible tentacular apparatus to the thick-walled tentaculitoids. However, the existence of a tentacular apparatus in the latter group should not be rejected. The possibility of a vertical sessile, suspension feeding mode of life during the adult stage is rather attractive in the light of Blind's (1970) paper and the present study. The subject merits special attention and will be treated further in a later section (p. 57).

The formation of septa at a comparatively late stage of growth could be more easily explained by postulating the existence of retractor muscles to control tentacles or other soft parts. In several taxa the last 3 or 4 septa, and particularly the last one, are always considerably thicker than those located more proximally. These septa possess bilaterally symmetrical impressions (Lardeux 1964: 5939; 1969: 11; and in this paper Fig. 13). It is reasonable to assume that the septa acted as areas of attachment for, e.g., muscles. In the early stages of adult growth the soft parts should have been less massive, when a rather thin septum would have been sufficient for attachment of the controlling muscles. As the tentaculitid grew, the volume of the soft parts should have increased. Accordingly, it required more voluminous muscles and larger areas of attachment, i.e. stronger septa. The phosphatized material from Ramsåsa 8, Scania, which had bilaterally symmetrical impressions in the septa, showed that the area of these impressions increased with each new septum formed. It is notable that species with comparatively large conchs, such as *Tentaculites hisingeri* and *T. scalaris,* develop massive endoconic septa. These species must have possessed rather voluminous soft parts compared with other slimmer species, and thus required correspondingly large controlling muscles and stronger septa.

The aperture of the conch wall will differ depending on the growth stage of the conch. It may lie either at a ring or in an interspace. At all stages of development the conch is very thin and fragile immediately before the rim. This thin development makes it easy to establish if the functional aperture is preserved or not. When the aperture coincides with a ring, this ring is always rapidly filled towards the inside by lamellae, probably to strengthen the shell at this point.

Blind's (1969: 108, 119–121) hypothesis that the aperture was protected by an operculum cannot be corroborated at all by the present study. Extensive material with well-preserved apertures both from Gotland and Scania, was carefully examined for this purpose. No specimen showed morphological features to suggest an opercular apparatus. If such an apparatus existed, it must have been constructed of a material which did not fossilize and, though connected to the conch, left no imprints on it.

Dimorphism

No characters were found which would suggest dimorphism, either sexual or functional.

Erdtmann & Yoder (1974) and Yoder & Erdtmann (1975) presented a case of supposed dimorphism among tentaculitids from the Devonian of North America. *'Tentaculites' attenuatus* Hall and *'Tentaculites' bellulus* Hall were considered dimorphs of one species. The proposed dimorphism was based on measurements in 86 specimens of breadth and height of rings and compilations of the breadth-height ratio. The authors suggested sexual dimorphism. The male form was thought to be characterized by isometric growth during the adult stage, when the female form was indicated by a change to an anisometric growth pattern.

I am not convinced that the two species measured by Yoder & Erdtmann really form dimorphs of the same species. I find the criteria used for the proposal rather weak. Firstly, the stressed co-occurrence in their material of *'Tentaculites' attenuatus* Hall and *'Tentaculites' bellulus* Hall is restricted to one single level (Yoder & Erdtmann 1975, Fig. 2). Hall (1879: 171) in his description of *'Tentaculites' attenuatus* emphasized the similarity to *'Tentaculites' bellulus,* but also pointed out the very great difference between the two species in abundance; the former species occurred in 'myriads', while the latter occurred only rarely. Another important point in Hall's descriptions is the vast difference between the two species in size.

Another doubt about the reliability of the criteria presented by Yoder & Erdtmann derives from examination of their graphs (Yoder & Erdtmann 1975, Fig. 6) showing the progressive changes in ratios of breadth-height of the primary rings. The scatter of the data points is wide, showing the ratios to be very variable. I am not convinced that mere comparisons of means of scattered ratios is sufficient grounds for proposing dimorphism. I have tested for possible dimorphism in closely related, co-occurring species, using the same method as Yoder & Erdtmann (1975). In no case have I been able to confirm their theory. A pattern of very dispersed ratios has been obvious.

The theory of dimorphism in tentaculitoids is not new. Novak (1882: 50–51) reported a case of possible dimorphism in some dacryoconarids. However, Novak himself seemed not entirely convinced because he emphasized that he could recognize a series of intermediates between the supposed dimorphs. Bouček (1964: 32) stressed intraspecific variation rather than dimoprhism for Novak's material.

If tentaculitoids are dimorphic, the characters should probably be looked for in the shape and development of the living chamber. It would require much well preserved material which could be used for detailed measurement of various size parameters. It is possible with some populations from Gotland, e.g. from the Mulde Beds at Mulde Tegelbruk 1. However, it is time-consuming and lies outside the scope of the present study.

Ecology and mode of life

Tentaculitids have generally been ascribed a benthic mode of life in contrast to the thin-walled dacryoconarids which are supposed to have been planktic. Many criteria for mode of life have been presented, e.g. thickness of the conch wall; presence or absence of camerae, morphology of the rings, symmetry, character of embedding sediment, abundance, character of concomitant fauna, etc. Some authors, e.g. Ljashenko (1959: 72), Fisher (1962: W103), have emphasized the occurrence in all kinds of environments, including aerated and stagnant conditions. Others, e.g. Bouček (1964: 157), Thayer (1974), found significant differences in distribution of the two orders. Thick-walled forms were restricted to shallow, well ventilated environments while thin-walled forms were considered significant for basinal and open shelf environments.

For the background to discussion of the ecology and mode of life of tentaculitids based on those from Gotland and Scania, a review of more recent literature is needed.

Ljashenko (1959: 72) considered tentaculitids to be nektic with the conch positioned vertically. The camerae were supposed to control the orientation because the animal could regulate their internal gas pressure. Fisher (1962: W103) stressed the tolerance to various environments. However, he also pointed out facies differences in abundance. There was a predominance in shales and argillaceous siltstones and decreased abundance in sandstones, greywackes, reef limestones and dolomites. Fisher tested different models for the mode of life of tentaculitids (Fisher 1962, W104–105, Fig. 51). He concluded that thick-walled forms were probably nektobenthic scavangers positioned with the apex upwards. The thick shell was considered a response to rough water in littoral environments. Bouček (1964: 157) also ascribed to the tentaculitids a benthic life in shallow environments with warm, well ventilated water. He suggested that the animal lived on the bottom, resting partly buried with the rings for anchorage.

The first and, hitherto, only published report on conchs vertically oriented in the sediment was submitted by Driscoll (1968). He described vertical, apex-down specimens of *'Tentaculites' bellulus* Hall in the Devonian Arkona Shale in Ontario, Canada. The conchs occurred in lenses in glacial drift but, from associated burrow fillings, vugs in brachiopod valves and eroded surfaces, the original orientation could be determined. Driscoll considered the find evidence for a benthic life with the apex partially buried in the substrate, and suggested that the tentaculitids were benthic or nektobenthic. He emphasized the difficulties of assessing mode of life and relationship to the substrate. He pointed to the concomitant fauna in beds with abundant tentaculitids; fossils typical of a neritic environment, e.g. brachiopods, trilobites, and ostracodes, yet the sparse co-occurrence with hyolithids and bryozoans.

Blind (1969: 137) favoured a semi-infaunal mode of life with a vertical, apex-down orientation of the conch. He based this on (1) conchs showing accumulations of pyrite and sediment on the distal side of septa, (2) the lack of initial chambers in the conchs, (3) septal development and its response to the character of the substrate (*Tonmergel-, Sandmergel-, Kalkmergel-Formen*), (4) small conchs found within the living chambers of large conchs. Several of Blind's putative pieces of evidence are highly controversial. In a subsequent paper (Blind 1970), more convincing evidence for an upright position was presented in discussion of the mode of attachment of epizoans on the tentaculitid conch. Epizoan distribution suggests convincingly a vertical, apex-down, semi-infaunal habit. In both papers, Blind postulated this mode of life only during the adult growth phase of the tentaculitid. Morphological criteria (Blind 1969) and the lack of epizoans on the juvenile part of the conch (Blind 1970) were taken as positive evidence for a free-swimming mode of life during the larval growth stage. The present study indicates Blind's interpretation to be possible. Blind (1969) gave no suggestion for the feeding mechanism. However, he postulated the presence of a tentacular apparatus. Recently, Blind & Stürmer (1977) described X-ray photographs of specimens of *Viriatellina fuchsi* (Kutscher) on which they distinguished tentacle arms ending in feather-like extension.

Walker & Laporte (1970: 939) and Walker (1972, Table 9) supposed tentaculitids to be deposit feeders or scavengers. In reconstructions of some intertidal settings during deposition of the Devonian Manlius Formation (Walker & Laporte 1970, Figs. 4, 5), tentaculitids were depicted resting on the bottom. They were interpreted as typical of low intertidal to very shallow subtidal environments, and were found to occupy the fourth position in the biovolume dominance (Walker 1972; Table 9). The tentaculitids were considered also to inhabit intermittently the high intertidal zone, moving with tides up and down the flats. Such a model is suitable only for a free-living animal. It hardly fits the view presented in this paper, of a semi-infaunal mode of life. The occurrence of tentaculitids in an environment which shows mudcracks, algal mats and interbeds of carbonate pebble-conglomerates (Walker & Laporte 1970: 939) complicates the hypothesis. I have examined no such environment, and consequently it is difficult to judge the significance of this type of occurrence. Walker & Laporte (1970) reported, from the same environment, frequent burrowers which were capable of withstanding periodic exposure of the sea floor. If tentaculitids possessed the same ability, they must have been inserted completely into the sediment. Such a theory, for other reasons, seems unlikely.

Berger (1974) supported Blind's (1969, 1970) hypothesis of an upright, apex-down orientation of the conch. He stated, without further explanation, that the proportion between the lengths of the juvenile and adult parts made impossible a horizontal mode of life (Berger 1974: 138). He claimed (p. 140) that vertically oriented conchs had been found, but unfortunately did not submit any details. The development of oblique septa and rings and curved profile of many conchs were regarded as responses of the conch to the orientation in the substrate. Berger (1974: 139) supported Blind's theory that larval forms of tentaculitids, to continue development, occupied empty, but still vertically standing, conchs of the same species. For proofs, Berger noted observations of inserted conchs with distal diameters larger than the diameter of their "housing" conch (Berger 1974, Fig. 2). According to Berger, inserted conchs exhibited comparatively thinner walls and smoother external ornamentation because they had not been directly influenced by the environment. Berger (1974: 137) noted that the central or subcentral position of the inner conch, i.e. having a more or less common axis of symmetry with the outer conch, excluded the possibility of mechanical sorting for the cone-in-cone occurrences. If the inserted conch had a marginal position and a random orientation its occurrence was caused by bottom currents.

It is not easy to appreciate fully Berger's arguments and I find his theory very speculative and improbable. I cannot see how the tentaculitid animal, which probably had a moderate level of organization, would be able to select empty conchs of the same species. Cone-in-cone occurrences of conchs are rather common in various strata, and there are good indications that bottom currents are largely responsible.

Berger (1974: 137) suggested a link between the occurrences of tentaculitids and the character of the substrate. As the proportion of terrigenous material in the sediment increases, the number of tentaculitids decreases. They do not occur at all in sand- and siltstones. The same inverse trend was found with increasing dolomite. Hence, Berger suggested that tentaculitids were sensitive to changes in salinity.

Thayer (1974) calculated the proportions of various fossil groups in different environments of the Genesee Group, Upper Devonian of New York. He found basic differences in the distribution and abundance of tentaculitids and styliolinids. The abundance of tentaculitids was more than 7% of the total fauna and in this they were superceded only by brachiopods and bryozoans. Styliolinids constituted almost 2% of the total fauna. The 7% value is much higher than the figures published by Hurst (1975) who calculated abundances for tentaculitids of 0.2, 2 and 3.7% of the total fauna in the Mulde, Klinteberg and Burgsvik Beds of Gotland, respectively. For the present study no similar calculations were made because such a survey would have been too time-consuming and beyond the scope of this monograph. Besides, the fragmentation of the conchs sampled makes difficult such a survey. However, it is my impression that, in certain environments and at certain horizons, tentaculitids constitute a major macrofossil group by number of specimens, perhaps only superceded in abundance by bryozoans, brachiopods, echinoderms and ostracodes. Such levels where tentaculitids are prolific occur, e.g., at Gothemshammer in the Halla Beds and at Mulde Tegelbruk 1 in the Mulde Beds. Accordingly, the fossil assemblage at the latter locality was designated a 'cricoconarid-palaeocope fauna' (Martinsson 1967: 365). Thayer (1974: 130, Figs. 5, 6) also noted the occurrence of abundant tentaculitids together with "epifaunal ostracodes". This association he considered to be significant for a "delta platform" environment and particularly for "near shore" environments. Styliolinids were noted to be restricted to basin and open shelf environments. Thayer (1974: 132) concluded that tentaculitids should be placed among benthic deposit feeders, while styliolinids were regarded as planktic suspension feeders (p. 130). Thayer gave no evidence of his own for these assumptions but based his statements on previous publications, e.g., Fisher (1962), Lardeux (1969), Walker & Laporte (1970). Thayer did not comment on the relationship of the tentaculitids to the substrate. However, from one reconstruction (Fig. 18G) of the ecological setting of some body fossils, it may be concluded that he considered the tentaculitids either rested on the substrate or were nektobenthic. The tentaculitids are reconstructed with a tentacular apparatus while the stylionilids (Fig. 18A) appear pteropod-like.

A nektobenthic mode of life was also suggested by Yoder & Erdtmann (1975: 375), because of the radial symmetry thought to characterize the conch and because of the development of the septa. They interpreted the restricted occurrence of thick-walled tentaculitids in epicratonic to marginal shelf, shallow-water environments as a positive indication of a functional and ecological relation to epibenthic assemblages. However, they pointed out, without more evidence, that many thin-walled tentaculitids occur together with thick-walled forms in shallow water communities.

In an attempt to reconstruct the biology of the tentaculitids, Hurst & Hewitt (1977) used data obtained from quantitative descriptions of facies conditions as revealed by the sediment. The tentaculitid treated was *'Tentaculites' anglicus*. The systematic position of this species within the tentaculitids is still unknown and some authors, e.g. Bouček (1964: 50), have even considered it a cornulitid. However, my examination of the type material and of material collected from localities in the Caradoc district, England, show indisputably its true tentaculitid affinity. Hurst & Hewitt (1977) gave many important general notes on the functional morphology and relationship to substrate of various invertebrates with elongate bodies. They made comparison with certain characters of the tentaculitid conch. The strong transverse external ornament of the conch was regarded to exclude the tentaculitids from deposit feeders. Hurst & Hewitt (1977: 164) postulated instead that tentaculitids were suspension feeders using the rings as anchoring devices in the substrate. The lack of epifauna on the conchs was taken as evidence of a fully infaunal mode of life for *'Tentaculites' anglicus*. They suggested (1977: 165) that the absence of vertical conchs *in situ* in the sediment was a result of bioturbation. This is an interesting conclusion and must be considered for the Silurian sediments studied here, bearing in mind especially the common occurrences of epifaunal as well as infaunal deposit feeders in the samples with tentaculitids.

Summarizing the ideas reviewed above, one may conclude that most authors consider tentaculitids to be benthic. Thus the group is differentiated from the planktic dacryoconarids. Various views are held of the more detailed benthic habit, whether epi- or infaunal. Mostly the views link with the discussions on the supposed feeding habit, i.e. whether they are deposit or suspension feeders. The latter view dominates in more recent publications.

In reconstructions of ancient environments and the ecology of a particular organism, the question of post-mortem transport is critical. The present study shows it to have been negligible, so that the thanatocoenoses found more or less represent the *in situ* dwelling occurrence of the tentaculitids within their actual niches. This conclusion stems from the generally good preservation of the conchs, which show very little wear. Admittedly, much of the material studied is fractured. However, it is believed that fracturing occurs easily among such, elongate, conchs; the preparaton of the marly samples supported this belief. Much of the concomitant fauna is also fractured and disarticulated. Probably, rather moderate wave and current agitation could fragment shelly material easily in neritic environments. The action of scavenging and burrowing organisms could contribute partially to fragmentation. An absence of long transport is supported by the unsorted character of the tentaculitid remains. Hurst (1975: 260) concluded that the benthic assemblage of the oolitic limestone at the top of the Burgsvik Beds was an offshore one. He suggested that it had been transported towards a shallower environment which is indicated by the nature of the sediment. The few tentaculitid remains found in these oolites also show evidence of being transported; they are worn and completely encapsulated by calcareous laminations. The only species of which few specimens have been coated by laminations is *Tentaculites hisingeri*. It also happens to be one of the largest species on Gotland and it is believed to have been able to withstand more agitated water than other tentaculitids. Except for this occurrence of transported conchs described, no signs of longer transportations have been observed.

All shells with a predominant long axis which rest on the sea bottom in neritic environments get influenced easily by wave action and currents. Tentaculitids are such a group. They have not been used often as current indicators although many current-affected occurrences have been recorded, e.g. in Ljashenko (1959). Kindle (1938) and Jones & Dennison (1970) are among the few who have demonstrated the usefulness of tentaculitids for establishing directions of currents. During the present study few occurrences of current oriented tentaculitids have been observed. I have found only one example in Scania, at Klinta 1, where a surface at 2.55 m in the measured section (Jeppsson 1974) exhibited orientated tentaculitids. On Gotland I know of only one occurrence, i.e. at Haganäs 1 in the Slite Beds, where a surface of 2 m^2 yielded many hundreds of tentaculitids orientated together with fossils from many other groups. This surface is being examined by Claes Bergman, Lund. Among the many fossils showing preferred orientation, two crinoid crowns deserve mention. These crowns are not fragmented and arms and pinnulae are well preserved. This indicates that transport was not a long way. The fossils probably represent an assemblage oriented by wave agitation along an axis perpendicular to the shore.

There is other evidence to indicate that current and wave action have influenced the tentaculitids to some degree. Frequently conchs are found inserted into one another, either apex or aperture first. Occasionally three or even four inserted conchs form cone-in-cone structures. The latter have only been observed among masses of tentaculitids. One needs no other cause for development of the cone-in-cone structures than the action of waves and currents. There are other opinions, e.g. Blind (1969) and Berger (1974). I disagree with their interpretation, as was stated earlier (p. 36). Cone-in-cone structures are not uncommon among elongate conical fossils, e.g., in many Cambrian strata where various kinds of enigmatic conical tubes abound. My own observations include in the Lower Cambrian oncolitic limestone at Sörsjön, Jämtland, which yields numerous calcareous conchs inserted into one another. Similar occurrences have been described, e.g. in Rozanov *et al.* (1969, Pls. 14: 2, 7; 16: 2) and Valkov (1975, Pls. 3: 9, 7: 1–5). Cone-in-cone occurrences have been reported in dacryoconarids (Bouček 1964, Pl. 22: 5–6), which are generally considered planktic, and where mutual insertion must have been post-mortem.

Tentaculitids on Gotland and in Scania show various patterns of occurrence in different environments depending on shifting environmental conditions. The critical parameters seem to have been water depth, type of substrate, water turbulence, and supply of food and oxygen.

I shall not make a systematic review of the detailed distribution of tentaculitids within all lithological or stratigraphical units on Gotland and in Scania. This is mainly because we are still embarassingly ignorant about the sedimentology of many units with regard to properties such as grain size, cementation, ratio of carbonates/clastics, compaction etc. Hence also, the terminology for many lithologies is still floating. To give one example, the term marl is used for several kinds of rocks on Gotland but there has never been any general agreement on what constitutes a true marl or marlstone in the various beds there.

Tentaculitids have been observed on Gotland in all stratigraphical units except for the Tofta Beds. In Scania occurrence is restricted to the Öved-Ramsåsa Beds and a few levels in the *Colonus* Beds.

In general the most prolific occurrences are in lithologies of interbedded argillaceous limestone, marl, marlstone and calcareous mudstones. Such lithologies on Gotland are found in most established stratigraphical units. Such levels include e.g. the Visby Beds, Högklint Beds unit *b*, Slite Marl, Mulde Marl, Halla Beds unit *c*, Hemse Marl, Eke Marl, Hamra Beds unit *b*. In Scania the same lithologies with abundant tentaculitids occur in the Öved-Ramsåsa Beds, unit *1* and the lower part of unit *3*. Purer limestones seldom have more than scattered fragments of tentaculitids. However, as soon as the mud content increases the number of tentaculitids increases too. Thus, the purer limestones of the Högklint, Slite, Klinteberg, and Sundre Beds have yielded very few specimens. This is particularly true of the crinoidal limestones and limestones rich in stromatoporoids. Hurst & Hewitt (1977: 151) also noted the sparse occurrence of tentaculitids in carbonates. Reef limestones seem almost to lack tentaculitids. The few conchs obtained from reefs derive from intercalated marl pockets, and generally appear reworked. Tentaculitids are also lacking in the coarse detrital limestones surrounding the reefs. However, Manten (1971, Tables IX, XVII, XVIII) reported tentaculitids from reefal and crinoidal limestones on Gotland, although no mention was made of their abundance or state of preservation.

Siltstone and sandstones commonly show poor tentaculitid faunas. Exceptions are found in argillaceous levels of the Burgsvik Sandstone, e.g. at Uddvide 1 and Klasen 1, where tentaculitids together with bivalves form the major constituents of the fossil fauna. In lithologies with less mud content such as the Slite Siltstone and, in the Öved-Ramsåsa Beds, the yellow sandstone unit *2* and parts of the Öved Sandstone unit *4*, no tentaculitids have been found. All tentaculitids obtained from the Öved Sandstone derive from thin accumulations of calcareous skeletal remains of marine faunas, or from muddy intercalations as found e.g. in the Ramsåsa area. Otherwise the Öved Sandstone unit is considered non-marine (Gray *et al.* 1974: 263). It is worth mentioning that one frequently finds the largest tentaculitid species in sandstones or sediments which indicate agitated water conditions. This is demonstrated, e.g. in the Burgsvik Beds, by the abundant occurrence of *Tentaculites hisingeri* yet low abundance of *Lonchidium scanicum*. In contemporaneous argillaceous beds in Scania, the latter species dominates the fauna. Perhaps this is an example for Boucot's statement (1975: 51) that quiet water taxa commonly tend to be smaller than rough water taxa, regardless of benthic assemblage.

Oolites are practically devoid of tentaculitids. No specimens have been encountered in the Bara Oolite of the Halla Beds despite extensive sampling. In the Burgsvik Oolite some conchs have been found, but they have mostly been reworked and are encrusted by thin carbonate laminations. Specimens showing no signs of having been reworked all derive from small argillaceous pockets within the oolite.

A special distribution of tentaculitids is seen in the dark, fine grained, commonly bituminous mudstones and argillaceous, fine grained, lagoonal limestones which form between the Högklint reefs at e.g. Ireviken and Lickershamn, in unit *d* of the same beds in the section at Vattenfallet 1 and in unit *b* of the Halla Beds at Hörsne. All these beds practically never yield any tentaculitids except for varous species of *Alternatus?*, but these locally, e.g. at Hörsne 1, occur abundantly.

The shales constituting the Llandoverian, Wenlockian and most of the Ludlovian sequence in Scania have yielded practically no tentaculitids. The faunas obtained derive exclusively from interbedded limestone or mudstone units which have a shallow water character, i.e. at Skarhult 1 and Röddinge 1. The non-graptolitic shales forming the basal and middle parts of the Öved-Ramsåsa Beds generally show good tentaculitid faunas, especially at levels with mudstone or argillaceous limestone. These sediments clearly have a shallow water aspect as is indicated by the prolific concomitant fauna and flora (cf. Grönwall 1897). The algal limestone lens forming the upper part of unit *1* of the Öved- Ramsåsa Beds at Bjärsjölagård has not yielded many tentaculitids, but the equivalent muddier beds at Klinta generally exhibit prolific tentaculitid faunas.

In the stratigraphic units of Gotland, one may find differences in abundance along the strike of the beds. This is clearly seen in the Högklint, Slite, Halla/Mulde and Hemse Beds. The abundance distinctly decreases towards the southwest. This accords with the change towards the southwest from calcareous to argillaceous facies (Martinsson 1967: 383). This change may be ascribed to a general deepening of the basin in this direction for a considerable part of the Silurian. It is known (Martinsson 1967: 383, Skoglund 1968) that a marked change in facies occurs towards the southeast as well. All units with reefs and limestones in the northwest gradually become more argillaceous and finally in the SE consist of graptolitic shales with thin intercalations of limestone. So far, no tentaculitids have been reported from the cored interval of the Silurian beds in the När borehole in southern Gotland (R. Skoglund, personal communication, 1978).

From the description of the general distribution pattern of tentaculitids in the sediments of Gotland and Scania, it is possible to elucidate some environmental settings in which tentaculitids thrived or which they avoided. Since there are no known recent descendents of the group, their ecology must be reconstructed entirely from data of morphology, the nature of the embedding sediment and the concomitant fauna. The quality of the data varies, especially the sedimentology. No quantitative data for abundance of the tentaculitids are given, except in very broad terms. Thus, the following interpretation of the ecology is based on observations made during examination of the samples and on impressions gathered during several years of field work within the two principle areas. Analyses of the concomitant faunas are also incomplete because neither time nor knowledge has permitted full identification of all faunal components.

Some principal environmental factors, i.e. depth, substrate, wave and current action, will be discussed. There are other factors, e.g., supply of food, that could be discussed but only speculatively; these are avoided in this paper.

Comparison of contemporaneous strata on Gotland and in Scania, or even within stratigraphical units on Gotland, shows that the distribution of tentaculitids was greatly influenced by bathymetric conditions and the nature of the substrate. Tentacualitids are restricted to sediments whose fauna and lithology are typical of shelf environments. This includes most of the muddy sediments on Gotland which have neritic faunas and floras. In other shallow water sediments, such as those with ripples (e.g. at Gannes 1 and Klintebys 1 on Gotland, Bjärsjölagård 1 in Scania), oolites (Gotland), conglomerates (Gotland) and certainly the reefs on Gotland and biostromes in Scania, the tentaculitid faunas are always poor or lacking. Here, another factor, probably wave and current action, must be considered. Certainly, this factor is closely connected to the depth and substrate conditions. It seems likely that the water energy was too high to allow the tentaculitids to rest stably if they lived partly inserted into the substrate. The relation of the faunas with mud content of the sediment suggests that water movement was important. Muddy limestones, marls and mudstones provide prolific faunas, while winnowed skeletal limestones contain few tentaculitids. The same trend, although less pronounced, may be seen in sandstones. Thus, it may be concluded that tentaculitids preferred environments of moderate to low water energy. In terms of brachiopod communities, maximum abundance is found in the *Eocoelia* community (Ziegler 1965) or Benthic Assemblage 2 (Boucot 1975). It is interesting that the 'Tentaculitid community 1' recognized by Boucot (1975) in the Devonian falls within this environmental setting. Boucot defined this community as occurring in a very specialized, quiet water environment with low diversity fauna.

It is rather hard to define upper and lower depth limits for the tentaculitids within these environments, especially as the views advocated on depth limits for brachiopod communities are now being questioned (for a discussion see Hurst 1976, Johnson & Potter 1976; and Shabica & Boucot 1976). Fortunately, there are depth indicators other than brachiopods. Combining these with some brachiopod studies (Hurst 1975) one may suggest, at least tentatively, the depth. For Gotland, Gray *et al.* (1974) and Hurst (1975) recognized all the benthic assemblages which are defined on the distribution of brachiopods. Comparing the distribution of spores, chitinozoans and acritarchs, Gray *et al.* (1974) concluded that the rock units were deposited under depth conditions shifting within the range from less than 10 m to a maximum of 200 m. A close correlation, particularly between spore occurrence and water depth (shoreline proximity), was emphasized. In their Table 1, some figures for depth were given. Benthic Assemblages 1 and 2 were considered to represent high and low intertidal positions respectively, with a maximum depth of not more than 10 m between mean high and mean low water. Benthic Assemblage 3 was considered to extend to the lower limit of the photic zone, i.e. approximately 70 m, as indicated by abundant calcareous algae and reef formation. Benthic Assemblage 4 and 5 were thought to extend to the limit of the continental shelf, 175–200 m below sea level. However, it is important to mention that there is no evidence yet from Gotland that tidal conditions existed in the Silurian. Thus, one cannot directly apply the Benthic Assemblages given in Gray *et al.* (1974) in terms of depths with reference to high and low tides. This is particularly so while no sedimentological criteria for tidal conditions can be matched with evidence from the brachiopod communities. Whatever the depth figures for the various sedimentary environments on Gotland, one may tentatively conclude that tentaculitids preferred waters in the upper part of the shelf, i.e. in depths from a few metres to, say, 50–70 m, with maximum abundance in the shallowest part.

Published accounts of the distribution of tentaculitoids emphasize the distinctly shallow water nature of the thick-walled forms, e.g. Thayer (1974). Also, Bouček (1964: 158) stressed strongly the total absence of thick-walled tentaculitoids yet the prolific occurrence of thin-walled dacryoconarids in the Silurian to Devonian of Bohemia. Bouček ascribed this entirely to bathymetry.

A factor of very great importance for the distribution of tentaculitids is the nature of the substrate. This factor depends largely on depth, shore-line proximity and turbulence of the water. The greater abundance of tentaculitids in mud-rich, shallow water sediments and their sparse occurrence in skeletal limestones, reefs, etc., suggest that the tentaculitids required soft bottom sediment for their benthic habit. This assumption seems logical in view of the mode of life proposed, with the proximal part vertically or sub-vertically inserted into the substrate. As the conchs show no signs of attachment surfaces, it seems doubtful if tentaculitids had the ability to colonize hard bottoms or bottoms with coarse skeletal debris. Blind's (1969) suggestion that tentaculitids developed different types of septa according to the substrate cannot be supported. I regard the different types of septa as having purely phylogenetic origin.

The response of tentaculitids to physical and chemical properties of the water, i.e. temperature and salinity, can only be estimated. In the areas studied, the sediments which include bahamitic carbonates and reefs, the flourishing fauna and flora and the proximity to the palaeoequator, are generally thought to indicate warm-water environments through most of the Silurian. It may be concluded from the lithologies that conditions of extreme salinity did not prevail. Tentaculitids seem to have preferred well aerated waters. Less aerated waters, e.g. those of lagoonal areas, were only inhabited by species of *Alternatus?*, This genus seems to have been tolerant, as is indicated by its numerous occurrences in most environments on Gotland. It is striking that no representatives of the genus have so far been encountered from the Öved-Ramsåsa Beds in Scania, although the physical conditions indicated in these beds were comparable to those of Gotland units.

In earlier chapters I mentioned briefly that I support Blind's (1969) idea that thick-walled tentaculitids were benthic, living with the proximal end inserted in the substrate and the conchs vertical or sub-vertical, i.e. semi-infaunally (West 1977). This conclusion is reached from examination of the external and internal morphological characters of the conchs in the Silurian material from Gotland and Scania. Other data I consider important are Driscoll's (1968) observation of vertical, apex-down tentaculitids, and the presence and orientation of epizoans on the tentaculitid conch as described by Blind (1970) and myself herein. From the epizoans I conclude that tentaculitids did not have their hard parts fully inserted in the substrate. This conclusion differs from the view expressed by Hurst & Hewitt (1977: 164, Fig. 7A), who inferred the whole conch to be inserted in the substrate. Several species, e.g. *Tentaculites liquis, T. obstipus* and *T. loxus,* have oblique rings. These could possibly indicate a subvertical life position for the conch, to maintain the aperture parallel to the water surface. The lack of vertical conchs, i.e. in life position, in the sediments examined is of course problematic for this theory. However, fossil specimens of infaunal animals are rarely found in life position in the sediment.

From the morphology of the tentaculitid conch and the ecology postulated, I propose that, during their adult growth phase, tentaculitids were suspension feeders in the sense of Walker & Bambach (1974, Table 6). This assumption can only be speculative because practically nothing is known about the soft parts of the tentaculitid animal. However, from the anatomy of the hard parts, one may deduce something of the general organization of the soft parts. These ideas have been presented in an earlier chapter (p. 51). It seems unlikely, considering the semi-infaunal mode of life proposed, that tentaculitids belonged in a different trophic group. Carnivorous feeding is precluded by the small body volume.

Systematic position

The feeding habit and ecology of tentaculitoids is strongly linked to the question of the affinity of the group. This is an ambiguous subject which it is very difficult to discuss positively. Suggestions have been put forward in numerous papers and this hardly increases the attraction of discussing it more extensively or of launching another idea about their systematic position.

Over the past century tentaculitoids have been referred to several phyla, but no convincing evidence which settles the systematic position of the group has been presented. Particularly the phylum Mollusca has attracted many authors as a possibility, when pteropods and cephalopods have mainly been suggested as closely related groups. Here is not the place to outline all views on the affinity. I am also rather hesitant to launch any firm opinion because I am convinced that more investigations of morphology and ecology of the tentaculitids are needed first to provide the basis for a sound proposal.

Although I am not assigning the tentaculitids to phylum, I cannot avoid remarking on a few recent papers which refer the group most categorically to the molluscs, using evidence and interpretation which I consider mere speculations. I refer to the papers by Blind (1969, 1970), Brassel *et al.* (1971), Alberti (1975) and Blind & Stürmer (1977). These papers are frequently cited and the interpretations accepted. I will comment briefly on the major points which are used to support the hypotheses and draw attention to some conclusions which are questionable.

The authors mentioned presented several characters of the tentaculitoid conch to support a molluscan affinity, and inferred a particularly close relationship to the cephalopods. The major criteria were (1) the three-layered construction of the conch wall (Blind 1969; Alberti 1975), (2) the presence of a nacreous layer, originally of aragonite crystals but now transformed into pseudohexagonal tabular calcite crystals (Blind 1969) or still remaining its aragonitic character (Alberti 1975), (3) the presence of funnel-shaped septal necks (Blind 1969) and a siphuncular cord (Blind 1969; Blind & Stürmer 1977), (4) the presence of an operculum (Blind 1969; Blind & Stürmer 1977), (5) the development of a tentacle apparatus (Brassel *et al.* 1971; Blind & Stürmer 1977). Besides, Blind (1969) claims characters such as the development of the inner organic layer, the phylogenetic change in shape of the initial chamber from conical to vesicular, the bilateral arrangement of the septa, the straight, conical shape of the conch and its concentric growth, all constitute further support for a molluscan affinity.

Comments will be focussed on the five major criteria listed above. Firstly, the three-layered construction of the conch wall admittedly shows similarities to that in the molluscs, but this basic construction, variously modified, may also be observed in other fossil groups, e.g., arthropods, brachiopods. The conch wall in styliolinids (Alberti 1975) has an inner prismatic layer, which is foreign to molluscs, and in tentaculitids prismatic layers are lacking entirely. The interpretation of the nacreous layer in the tentaculitoid conch must be seriously questioned because a condition of its formation is the presence of aragonite crystals which, in my opinion, have never developed in the tentaculitoid conch. Blind (1969) meant that the tabular pseudohexagonal calcite crystals seen today in the conch are the result of a diagenetic phase transformation of aragonite crystals into calcite crystals. But, if the shell structure were primarily aragonitic, one would hardly expect to find such well preserved microstructures in the tentaculitid conchs as were seen in the material examined. There are no indiciations of recrystallization, but there is good reason to assume that the tentaculitid conch was composed of primary calcite. No molluscan classes are known to possess a primary calcitic shell, neither is it likely, that this was the case in the past. Thus, from the composition and microstructures of the tentaculitid conch I am satisfied to exclude completely a molluscan affinity.

The present study shows that there is no evidence that tentaculitids possessed perforated septa or septa with septal necks. The free parts of septa may occasionally show irregularities but they are always clearly imperforate, particularly seen with SEM techniques. I conclude this from having studied several hundred sectioned specimens with septa. Other published illustrations of sectioned tentaculitid conchs also show this, e.g. in Lardeux (1969). It contrasts considerably with Blind's (1969: 123–125) statement that almost every conch sectioned by him showed septal necks and that these structures were typical for the genera *Tentaculites* and *Volynites*. His statement is definitely not valid for the former genus, as is shown herein.

The presence of a siphuncular cord in tentaculitoids was proposed by Blind (1969: 125), Pl. 18: 6), Brassel *et al.* (1971, Fig. 2), and Blind & Stürmer (1977, Figs. 1–4). Blind's illustration is not very convincing because the structure proposed to be a siphuncular cord is very diffuse and besides is located within the living chamber. If the structure were to have penetrated the free parts of the septa it would have been more credible. More distinct are the elongate structures found in the juvenile part of the dacryoconarid *Viriatellina fuchsi* (Kutscher) by X-ray methods (Brassel *et al.* 1971, Fig. 2, and Blind & Stürmer 1977, Figs. 1–4). The latter authors make direct comparison with the siphuncular cord in cephalopods. It is difficult to evaluate whether these structures had an organic origin, as was suggested by Blind & Stürmer (1977: 519), or if they emanate inorganically. I will not exclude the latter possibility because tentaculitids commonly have longitudinal fractures, often with a regular course parallel to the axis. This is common in many dacryoconarids, of e.g. Bouček (1964, Pls 5: 3–5, 9–10, 19, 31, 37, 39: 3). Such conchs sectioned commonly show, in the interior, embedding sediment which has entered along the fracture and various precipitated minerals, particularly pyrite. There is a good chance for high contrast between the invading material and the original filling substance and the former will show up as an elongate body under X-ray. The number of compressed tentaculitoid conchs is certainly larger in compacted sediments, as was demonstrated clearly by Bouček (1964). Thus, it is not unusual that the dacryoconarids examined by Brassel *et al.* (1971) and Blind & Stürmer (1977), which derive from lower Devonian shales, are compressed and exhibit longitudinal fractures. That the suggested siphuncular structure is in the proximal part of the conchs could be explained by the living chambers being largely filled with pyrite which has hindered compaction of this part of the conch. This is clearly demonstrated in a figure by Kutscher (1964, Pl. 15: 2) which was subsequently reproduced in Brassel *et al.* (1971, Fig. 1). Similar phenomena are seen in my material from Gotland and Scania, but it is more common that longitudinal fractures occur in the distal part of the conch. The presence of septa in these tentaculitoids decreased the likelihood of compression of the proximal part.

Another fact which to my mind makes impossible the presence of a siphuncular cord in dacryoconarids, and which forms one of the major diagnostic characters for this group, is the total lack of internal septa. A siphuncular cord cannot exist if no septa are present. Despite this, Blind & Stürmer (1977: 517, 519) discuss certain structures in X-rayed specimens of *Viriatellina fuchsi* (Kutscher) in terms of septa!

Irrespective of the various interpretations of this structure in the proximal part of the conch, it clearly cannot be used as evidence for a molluscan affinity for the tentaculitoids. As long as no similar structure is proved in the thick-walled forms it can definitely not be used to discuss their position.

Blind's (1969) much cited note that tentaculitoids possessed an operculum has formed further evidence for a molluscan affinity. As discussed in an earlier chapter this interpretation is poorly founded and as yet there is no convincing proof of the existence of such a shell element in tentaculitoids. Thus it can hardly be used in discussion of molluscan affinity, especially as an operculate structure is absent in some classes of the molluscs and is not a unique to this phylum but occurs also in many other groups, e.g. corals, bryozoans and hyolithids.

Another structure definitely not unique to molluscs is a tentacular apparatus. One of the striking results of the X-ray studies described above of *Viriatellina fuchsi* is a structure in the distal opening of the conch which is interpreted as a tentacular apparatus. The illustrations by Brassel *et al.* (1971, Fig. 2) and Blind & Stürmer (1977, Figs. 1–4) look rather convincing and I am inclined to accept their interpretation that a tentacular apparatus is developed. But, as said previously, it does not follow automatically that this tentacular apparatus can be compared directly to the apparatus in cephalopods. I presume that several other types of tentacular apparatus, e.g. in annelids, bryozoans and phoronids, would appear similar if fossilized and subsequently detected by X-ray analysis. It remains to be proved that tentaculitids possessed a tentacular apparatus. However, by indirect evidence from morphological character in the conch, its presence seems likely.

From more general anatomical considerations, a molluscan affinity seems less probable. All known molluscan classes except the scaphopods have rather voluminous fleshy soft parts with well differentiated organs, commonly housed in spacious conchs. On the other hand, tentaculitoids have rather small conchs in the range from a few millimetres up to 6–7 centimetres. In medium-sized species of tentaculitids, the living chamber commonly attains a diameter in the distal part of ca. 1 mm and a length of 5–10 mm. This is certainly not an impressive volume for housing soft parts, especially if they had molluscan organization. I think the small size of the tentaculitoid conch, which has been neglected in discussions on affinity, should be considered in future discussions.

It is easy to criticize earlier hypotheses and views on the affinity of tentaculitoids, but such criticism is non-constructive if no alternatives are put forward. I am hesitant to voice a firm opinion on this subject because many unsolved problems remain. However, some ideas will be outlined.

The microstructures of the conch wall and certain morphological features of the living chamber suggest the presence of a tentacular apparatus. Therefore, I consider the tentaculitids may have been lophophorates, i.e. closer to brachiopods, bryozoans and phoronids than to other phyla. The inner bilateral symmetry demonstrated by septal impressions, the overall shape of the conch, the benthic, semi-infaunal, solitary mode of life which seems most likely, and the preference for shallow waters, these features make me inclined to regard the tentaculitids as closer to the phoronids than to the other lophophorate phyla. A serious problem, unfortunately, is that recent phoronids do not secrete a hard protective exoskeleton. Thus, direct comparison of the shell structures is impossible. Also, phoronids are unknown from the fossil record. However, they have a tentacular apparatus and a mode of life well in accordance with ideas on the mode of life of thick-walled tentaculitoids.

In a recent paper (Towe 1978) the hypothesis of affinity to the lophophorate group seems to have found some support based on observations of a cross-bladed fabric in the calcite layer of some tentaculitids. Towe tentatively suggested affinity either to articulate brachiopods or phoronids.

However, this hypothesis is not without problems, when the thin-walled tentaculitoids are considered. This group is generally regarded as planktic, which is not the case for the recent phoronids or other lophophorates. On the other hand, our knowledge on the microstructures of dacryoconarids and homoctenids is poor, which means that much remains to be done before we can either support or reject a lophophorate affinity for these two groups.

Basis of classification

The taxonomy of tentaculitoids is still unsatisfactory, especially among the thick-walled forms. This is not surprising considering the relatively few contributions to research of this group. The taxonomy used hitherto is based on work by Ljashenko (1955, 1957b–c, 1959, 1969a–d), Fisher (1962), Bouček (1964), and Lardeux (1969). The classificatory schemes of these authors differ to some extent, mainly at class and order levels. In consequence, a variety of opinions on the taxonomy are found in papers, depending on the choice of scheme. The main schemes were summarized by Lardeux (1969: 24–28; Tables 1, 2 and 4), to which reference is made for further discussion on aspects of tentaculitoid taxonomy. Bouček (1964) has also made many valuable conclusions on the prerequisites of tentaculitoid classification.

My investigation is limited to Silurian thick-walled tentaculitoids from only two areas in Scandinavia. Thus, I hesitate to carry out any detailed revision of the existing suprageneric taxonomy or to launch any new classificatory scheme. It is unavoidable that some classificatory matters must be remarked upon as a result of observations made during the present investigation. Changes with some diagnostic featurs added, will be found in the diagnoses for the various taxa.

I have tried to follow the taxonomy of Lardeux (1969, Table 4) with the inclusion of the new taxa presented by Ljashenko (1969a–d). The latter increased the number of tentaculitoid taxa immensely. Two new families and 18 new genera, three of which were reported from Silurian strata in Podolia, were erected. Unfortunately, the validity of these new taxa is not easy to judge because of the brief definitions and, especially, the very poor quality of illustrations. It is quite obvious that this has led to misinterpretations or doubtful interpretations of some genera in subsequent papers by other authors, e.g. in Hajłasz (1974). In the present paper some generic identification are doubtful as a result of these poor descriptions and illustrations. However, without better sources of access to type material, I provisionally assign some new species to genera erected by Ljashenko rather than erecting new genera. Time will show whether this is right when new faunas are described from Silurian strata of other areas.

Ljashenko (1969a–d) still maintains her original classification at class, order and family level, which contrasts considerably with the sceme proposed by Lardeux (1969). Some amendments to her classification are unavoidable to fit in with the more modern and logical concept of classification outlined by Lardeux (1969).

Of great importance to the taxonomic work is which criteria to use to define the various taxa and how to evaluate the taxonomic importance of the various morphological characters. It is obvious that the classification must be based entirely on geometrical configurations of the conch. There is still nothing known, which could contribute, about the soft parts in spite of the report of supposed soft tissues detected by X-ray examination of some Devonian dacryoconarids (Brassel *et al.* 1971; Blind & Stürmer 1977). Ljashenko (1959), Fisher (1962), Bouček (1964), and Lardeux (1969) discussed this in more detail and tabulated morphological characters which they considered to be important. There are differences in opinion among these authors with regard to the relative importance of various morphological elements. However, the following criteria are emphasized.

At order level are considered the structure of the wall, the formation of the initial chamber of the conch and the formation of the inside of the conch, i.e. the presence or absence of septa. Families are differentiated primarily by the formation of the surface of the conch, i.e. the rings and other sculptural elements. The development of the inner surface of the conch is also used at family level. Genera are recognized on the formation of rings and surface sculpture and on special characteristics of the inner surface of the conch. Bouček (1964: 31) lists three main criteria for distinguishing species, i.e. the special characteristics in the formation and arrangement of the rings and surface sculpture, the shape of the conch and the angle of growth, and the size and the dimensions of the conch. The two former criteria were considered important also by Fisher (1962: W108).

My material is limited to enabling me to judge fully the validity of the above mentioned criteria for distinguishing order. However, from the relevant literature the features listed, except for details, seem logical. It is commonly held that the shape of the initial chamber forms one of the important morphological characters on which the three tentaculitoid orders may be distinguished. However, that the various shapes are not limited to certain orders is shown by the present investigation and also by some previous papers. In the order Tentaculitida, and especially within the family Volynitidae Ljashenko 1969, several groups exhibit initial chambers with a more or less drop-like shape. This character is otherwise regarded as significant for the orders Dacryoconarida Fisher 1962 and Homoctenida Bouček 1964.

The development of the initial chambers is strikingly similar in the order Homoctenida and certain volynitids but the totally dissimilar wall structures of the two groups exclude any closer relationship.

The development of a bulb-shaped initial chamber in dacryoconarid tentaculitoids has been emphasized particularly by Fisher (1962) and Bouček (1964). Such initial chambers were regarded as missing in other small tubiform palaeozoic fossils. However, besides the above mentioned volynitids, a number of sedentary tubiform fossils of unknown systematic position show well developed initial chambers of this kind. This is clear from the vast number of minute sedentary tubiform fossils collected during the present investigation.

It seems that the main features for differentiation at order level should be the thickness and construction of the wall together with the presence or absence of septa. Thus, the order Tentacultida shows thick-walled conchs with a smooth or undulating internal wall surface to the living chamber which reflects very little or not at all the exterior sculpture, and well developed septa. The other extreme is the order Dacryoconarida which have thin-walled conchs whose internal wall surface reflects entirely the external ornament of the conch, and no septa. The third order, Homoctenida, seems somewhat intermediate, with a thin wall, an internal wall surface reflecting the exterior, and with few but distinct septa.

There are some features suggesting major differences in basic construction of the conch wall at least between the orders Tentaculitida and Dacryoconarida. Blind (1969) and the present investigation clearly demonstrate the three-layered construction of the conch wall where two organic layers embrace a calcitic lamellar layer. In some dacryoconarids, Alberti (1975) showed an entirely different construction with an outer prismatic layer, a lamellar "nacreous" layer and an inner prismatic layer. This observation is confined to some conchs of the genus *Styliolina* and other members of the dacryoconarids must be examined if this presumed basic difference between the orders is to be corroborated.

I am inclined to give the basic shape of the conch, i.e. straight or curved, a higher taxonomic value than it has been given hitherto. It is clear that tentaculitoids of many genera show a slight curvature during the juvenile growth stage, but when the curvature is maintained throughout growth, as in the new genus *Gotlandellites,* I think it justified to regard this feature as significant at least at a generic level. Undescribed faunas of curved tentaculitoids occur in the Llandovery of Wales and Anticosti Island. A new family is needed for such tentaculitids; thus the Gotlandellitidae is introduced. Distinctly curved tentaculitoids of Devonian age have been described previously from the order Homoctenida, i.e. *Homoctenus deflexus* Lardeux 1969 and *H. jaregae* (Ljashenko 1955). Internal structures have been described briefly only from the latter species, and thus it is not shown beyond doubt that the generic assignment is correct. Bouček (1964: 24) regarded curvature of a conch either as a specific feature or of teratological origin.

The assignment of tentaculitoids to a class is closely linked to their systematic position. Papers about classes in line with suggestions for zoological affinity are numerous. As a consequence there are various designations of class. Ljashenko (1955) created the class Conichoncha in Phylum Mollusca. The class embraced the tentaculitoids and the hyolithids. This view is maintained in all her subsequent papers and is shared by other authors, e.g. Hajłasz (1968, 1974, 1976). Joining tentaculitoids and hyolithids in a class has been criticized and rejected by Bouček (1964), Fisher (1967) and Yochelson (1961). Their papers together with new analyses of the morphology of hyolithids (Marek & Yochelson 1976) have shown convincingly that there is no logical reason to infer any relationship between and two fossil groups. Fisher (1962) created the class Cricoconarida for the thick- and thin-walled tentaculitoids. His diagnosis of Cricoconarida corresponds to that of subclass Tentaculitoidea Ljashenko 1957. However, the latter was raised to class level by Lardeux (1969). Bouček (1964: 45–47) also favoured the name Tentaculitoidea Ljashenko 1957 for all tentaculitoids. Unfortunately Bouček (1964: 45–47) only gave the name a rank of super-order. He created a new class, Tentaculita, to include tentaculitoids together with two other groups of tubiform fossils, the families Coleolidae and Cornulitidae erected by Fisher (1962). I regard this classification as entirely artificial and reject the class Tentaculita. I agree with Lardeux (1969: 3, foot-note 3) that we still know too little about the latter families to justify giving them a systematic position beside the tentaculitoids. Preliminary examination of sedentary tubiform fossils in the Silurian of Gotland show that the fossils which traditionally have been designated coleolids and cornulitids have many important morphological features which distinguish them clearly from true tentaculitoids. Another opinion was advocated by Blind (1972) who considered the tentaculitoids and cornulitids to be closely allied. Blind based his statement on supposed similarities of microstructure.

Blind (1969) assigned the tentaculitoids a systematic position close to cephalopods. He created the new subclass Tentaculoidea in the class Cephalopoda. This viewpoint was still maintained in a recent paper (Blind & Stürmer 1977). As several of Blind's criteria for placing the tentaculitoids among the cephalopods may be proved doubtful or unfounded, this new subclass can only be regarded as artificial and may be rejected.

I am inclined to follow the suggestion by Lardeux (1969: 24) to use the class designation Tentaculitoidea Ljashenko 1957. The name is undoubtedly the most suitable. It embraces only conchs which possess all the features characterizing "true" tentaculitoids and it is neutral with respect to the affinity of the group.

In the systematic descriptions I deliberately refrain from longer discussion of the identity and validity of taxa erected. Without proper illustrations and descriptions of many genera and species for comparison it is meaningless to discuss synonymies, especially where names erected previously are only in the text and not figured. It is obvious that many taxa could be revised and several could be merged or split up into new taxa. However, such work is not within the scope of the present investigation. As new faunas are described it will become possible to work out a more convincing classification of the tentaculitoids.

Class Tentaculitoidea Ljashenko 1957

Synonymy. – ☐ Super-order *Tentaculitoidea* n. super-order – Ljashenko 1957b: 84–85. ☐ Class *Cricoconarida* n. class – Fisher 1962:w109–w110. ☐ Class *Tentaculita* n. class (*partim*) – Bouček 1964: 50–51. ☐ Class *Tentaculitoidea* Ljashenko 1957 – Lardeux 1969: 29. ☐ Subclass *Tentaculoidea* n. subclass – Blind 1969: 141–142.

Nominate order. – Tentaculitida Ljashenko 1955

Diagnosis (emended). – Marine animals characterized by calcitic lamellar, thick- or thin-walled conchs, open at one end without operculum, closed at the other end. Size ranging between 1 and 80 mm. Conchs straight or curved, conical in shape, possessing bilateral symmetry, visible externally in the extreme proximal end, internally up to the last septum. Cross-section circular beyong the initial chamber. Narrow end of the conch with an initial chamber conical, drop-like or bulbous in shape, wide end with aperture without indented rim and perpendicular or oblique to the long axis. Exterior of the conch with or without transverse or longitudinal ornament. Interior of the conch with or without proximal transverse septa. Septa not perforate and camerae not connected with one another. Internal wall surface smooth or uneven. Life habit planktic or benthic.

Orders. – Tentaculitida Ljashenko 1955; Homoctenida Bouček 1964; Dacryoconarida Fisher 1962.

Stratigraphical and geographical distribution. – The members of the class are cosmopolitan and occur from Lower Ordovician to Upper Devonian.

Remarks. – The diagnosis essentially follows that of Lardeux (1969). However, it is extended to include important characters which characterize some members of the class, i.e. curvature over the entire conch, which is an important feature in the new genus *Gotlandellites* and in the dacryoconarid genus *Corniculina* Klishevich 1967. Furthermore, the absence of an operculum and the imperforate septa in septate tentaculitoids are important diagnostic features to distinguish the class from e.g. cephalopods (cf. Blind 1969).

Order Tentaculitida Ljashenko 1955

Nominate family. – Tentaculitidae Walcott 1886

Diagnosis (emended). – Thick-walled conical conchs, straight, occasionally with slightly curved proximal parts or curved along the full length. Length ranging between 1 and 80 mm, average 10–20 mm. Initial chamber conical or with a slightly drop-like, bilaterally symmetrical shape. Exterior of the conch ornamented with rings of equal or unequal size and spacing and with or without annulets in the interspaces. Lirae generally well developed. Interior divided proximally by transverse septa, either free or endoconic. Living chamber with smooth or undulating inner wall surface. Wall structure lamellar and thick, occasionally with well developed pseudopuncta. Benthic mode of life.

Families. – Tentaculitidae Walcott 1886; Volynitidae Ljashenko 1969; Rossiitidae Ljashenko 1969; Uniconidae Ljashenko 1955; Gotlandellitidae n. fam.

Stratigraphical and geographical distribution. – As for the class.

Remarks. – The diagnosis is extended from that by Lardeux (1969) to include the prominent curvature of some tentaculitids and the slightly drop-like shape of the initial chamber in some genera of the family Volynitidae. One character which may be significant for this order is the construction of the wall where two organic layers embrace a lamellar calcitic layer. It cannot yet be included in the diagnosis, because the wall structure in dacryoconarids has been examined in only one case (Alberti 1975) and not at all in the homoctenids.

Family Tentaculitidae Walcott 1886

Type genus. – *Tentaculites* von Schlotheim 1820

Diagnosis (emended). – Conical, thick-walled conchs, either straight or slightly curved proximally. Length on average 10–20 mm, exceptionally up to 80 mm. Initial chamber conical. Exterior with rings perpendicular or oblique to the long axis and gradually increasing in size and spacing towards the distal end. Annulets in the interspaces and on the distal slopes of the rings. Lirae. Interior divided proximally by transverse septa, free or endoconic. Wall surface of living chamber smooth or slightly undulating proximally, undulating distally. Wall structure lamellar, occasionally with pseudopuncta.

Genera. – *Prolationus* Ljashenko 1969; *Seretites* Ljashenko 1969; *Tentaculites* von Schlotheim 1820; *Tractabilis* Ljashenko 1969; *Tractabilopsis* n. gen.; *Ukrainites* Ljashenko 1969; *Uniformites* Ljashenko 1969.

Stratigraphical and geographical distribution. – As for the class and order.

Remarks. – The diagnosis is emended from those by Ljashenko (1959) and Lardeux (1969). Both authors included characters for members of the family Volynitidae. No new diagnosis for Tentaculitidae was given by Ljashenko (1969a) when genera earlier referred to this family were removed and referred to the new family Volynitidae.

The family Tentaculitidae is closely related to Volynitidae but differs in the absence of secondary rings between the primary rings. There is a clear tendency in the latter family to develop rhythmic ring patterns which have several rings in each cycle. In several of the genera erected by Ljashenko in 1969 and then referred to Tentaculitidae, weak cyclic arrangements may be observed, e.g. in *Turmalites* (1969a; Pls. 4: 1, 5: 1), *Parvulites* (1969a; Pl. 7: 3), *Sokolites* (1969a; Pl. 2: 3). Such cycles occur also in one of her new *Tentaculites* species, *T. polyconus* (1969a; Pl. 1: 6–7), where there is a conspicuous gradation in size of the rings (Pl. 1: 7). In *Bicingulites* (Ljashenko 1969a, Pl. 7: 7–9) a bi-annulate ring pattern is conspicuous in which the proximal ring of each pair is clearly a secondary ring. Thus, the character does not fit the diagnosis of Tentaculitidae but rather should be referred to Volynitidae. There is good reason to assume that *Bicingulites* is a junior synonym of *Lonchidium* d'Eichwald 1860. However, type material has not been examined so *Bicingulites* must at present be retained as an independent genus.

In *Parvulites* Ljashenko the shape of the initial chamber is clearly drop-like (Ljashenko 1969a, Pl. 7: 3). The genus should then be omitted from Tentaculitidae.

It seems that either some characters critical for the family Tentaculitidae *sensu* Ljashenko (1969a) are dubious or that some taxa should simply be referred rather to another family, preferably Volynitidae. The latter course of action is supported by the re-description by Zagora (1969) of *Tentaculites scalaris* von Schlotheim and consequently type for the entire family. In this species no cyclic pattern of the rings is observed but there is a continuous increase in size and spacing of the rings towards the distal end of the conch. There are still many matters to be cleared up and the systematics at family level are not yet entirely convincing. I tentatively refer the genera *Bicingulites* Ljashenko, *Parvulites* Ljashenko, *Sokolites* Ljashenko, and *Turmalites* Ljashenko to Volynitidae Ljashenko because the diagnosis of the family Tentaculitidae Walcott cannot embrace characters found in these genera. However, I must stress that I have not checked type material, only used information from the descriptions and accompanying illustrations.

Tentaculitidae is easily distinguished from the other three families. Rossiitidae, Uniconidae and Gotlandellitidae. It differs from the first by the undulating character of the inner wall surface of the living chamber and the ring pattern with only one type of rings, from the second in the size and arrangement of the rings and the interspaces, and from the third by the straight and larger sized conchs.

Genus *Seretites* Ljashenko 1969

Type species (by original designation). – *Seretites dobrovlensis* Ljashenko 1969; from the Lower Devonian Ivane Beds of Podolia.

Species on Gotland. – *Seretites? cataractae* n. sp., *S.? exilis* n. sp., *S.? versabilis* n. sp.

Remarks. – The diagnosis given in Ljashenko (1969a: 83) for the genus leaves much to be desired. The short account gives hardly any diagnostic characters which distinguish this genus. The figured holotype (Ljashenko 1969a, Pl. 3: 1) is unfortunately a thin section which does not give much information because of the poor quality of printing. Figures for the other two *Seretites* species. *S. astrovae* (Pl. 3: 2) and *S. ivanensis* (Pl. 9: 4–5), are similarly poorly printed. The latter figures show the external features and have been the main criteria for provisionally assigning some Gotland species to the genus.

From the illustrations cited the genus seems characterized externally by a narrow, conical conch, expanding in the proximal part at a growth angle of 7–8°. The conchs are medium-sized, straight except for the proximal part which occasionally shows a slight curvature. The ornament consists proximally of low rings which increase very slowly in size and spacing distally. The adult part is characterized by rings of one size which occur regularly and relatively close to each other, separated by interspaces with 1–3 annulets. The rings in the adult part seem to group but not in fixed positions (Pl. 9: 4–5). These figures of *Seretites ivanensis* also indicate that long interspaces may form distally. In profile the juvenile rings appear symmetrical and low with gently rounded crests. The adult rings are also symmetrical with crests that are rounded or slightly asymmetrical and convexo-concave (Pl. 3: 2a). However, the details of the rings are not easily seen on the figures of Pl. 3. All rings are perpendicular to the long axis. The juvenile part is divided internally by septa which on the holotype seem to be regularly spaced, straight and thin. The thin section of *S. astrovae* (Pl. 3: 2a) also shows regularly spaced septa, but with narrow free parts and thick mural parts which extend distally for a considerable distance. The prints unfortunately are too poor to give any detail of the septal structures. Neither do the descriptions of the three species give such information.

The brief summary given of the generic characters of *Seretites* is all that can be obtained from the published illustrations. There are many important details of the morphology which cannot be elucidated without study of the type material. However, the generic characters do seem appropriate to some species from Gotland which are therefore provisionally assigned to *Seretites?* Ljashenko, 1969.

Seretites? cataractae n. sp.

Fig. 24.

Derivation of name. – Greek *kataraktes,* waterfall, referring to the type locality at the section at Vattenfallsprofilen 1, Gotland.

Holotype. – SMNH No. X 1583, Fig. 24A.

Type stratum. – Högklint Beds, unit *b,* 19.50–19.60 m a.s.l. in the section at Vattenfallsprofilen 1.

Type locality. – Vattenfallsprofilen 1, Gotland.

Table 2. Seretites? cataractae n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1583 (holotype)	7.29		0.12		5.5°
SMNH X 1014	7.80	0.80	0.16		5.5°
SMNH X 1015	6.77		0.10		6°
SMNH X 1017	7.30	0.68	0.14		4.5°
SMNH X 1020	2.20	0.36	0.18		5°
SMNH X 1023	3.95	0.58	0.29	0.43	
SMNH X 1025	3.60	0.50	0.22	0.45	
SMNH X 1584	11.68		0.14		5°

Material. – From the type locality, 10 specimens from the Upper Visby Beds and 197 from the Högklint Beds; from additional localities, 9 specimens in the Upper Visby Beds and 53 in the Högklint Beds.

Diagnosis. – Straight, medium sized, *Seretites?* expanding proximally at 4.5–6°, distal part subcylindrical. Annulation consisting of three different patterns. Proximally with equally spaced, symmetrical rings, then more widely spaced rings with one annulet in each interspace. Distal part with regularly spaced rings separated by 3 or 4 annulets in each interspace. Lirae not crossing rings. Proximally with well developed, regularly spaced septa with straight free parts. Internal wall surface smooth proximally, distinctly undulating distally. Pseudopuncta unknown.

Description. – Straight, narrow conch with a proximal growth angle of 4.5–6°. Distal part subcylindrical. Conch medium-sized, maximum length estimated at 15–16 mm. Minimum outer proximal diameter 0.10 mm, maximum outer distal diameter 0.95 mm. No preserved initial chamber found. Aperture perpendicular to long axis.

Conch annulated in three principal modes. Proximal end with regularly spaced, symmetrical rings increasing gently in size and spacing distally. Crests of rings fairly sharp, often with a bi-concave profile. Interspaces separating rings smooth and concave. Density of rings 12–16 per mm. Distally in the juvenile part rings become more widely spaced and separated by concave interspaces which each have a central symmetrical annulet. Density of rings 6 per mm. Transition between the two ring patterns described takes place at an outer conch diameter of 0.20–0.25 mm. Distal part of conch with rings spaced at intervals of 0.25–0.50 mm and separated by slightly concave interspaces which have 3 or 4 annulets. This latter type of annulation begins approximately at the level of the last septum, i.e. at an outer conch diameter of 0.40–0.45 mm. Distal rings asymmetrical with straight or slightly opisthocyrt axial traces. Shape of rings convexo-concave. Hinge line commonly marked, forming the crestal line of the rings. Height: basal width generally 1:2. Distal annulets distinct, in profile often prosocyrt and triangular with pointed crest.

Tertiary interspaces and distal slopes of the rings, with well developed lirae crossing the annulets but not the

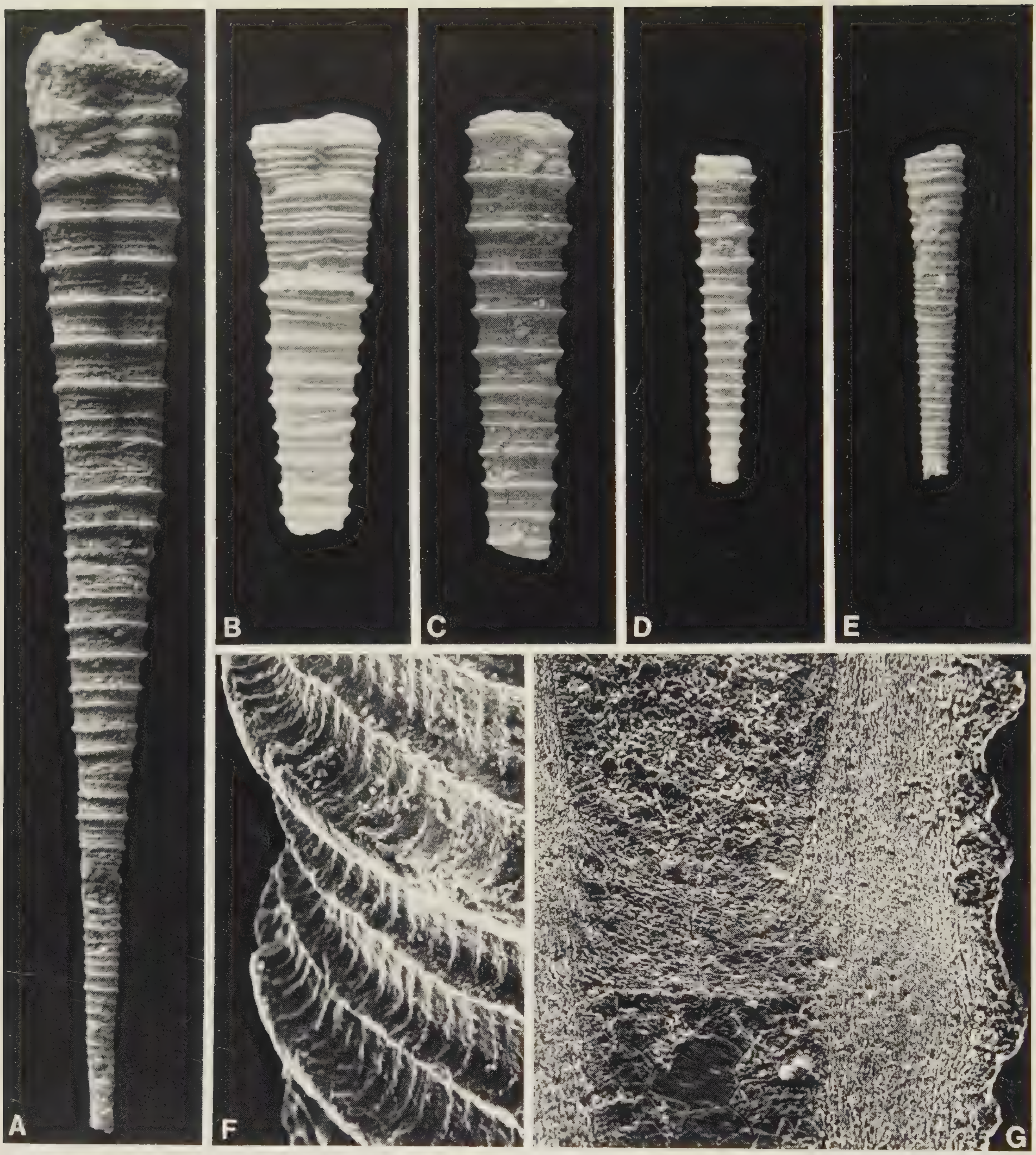


Fig. 24. Seretites? cataractae n. sp. A. Vattenfallsprofilen 1, 19.50–19.60 m. B, C. Vattenfallsprofilen 1, 19.80–19.85 m. D, E. Vattenfallsprofilen 1, 19.30 m. F. Gutevägen 1, MS 451. G. Lickershamn 1, MS 305. □ A. Holotype, SMNH X 1583, × 25. □ B. Specimen showing adult part, SMNH X 1018, × 25. □ C. Specimen showing early adult part, SMNH X 1019, × 25. □ D. Specimen showing late juvenile and early adult parts, SMNH X 1020, × 25. □ E. Juvenile part of conch, SMNH X 1684, × 25. □ F. Oblique apertural view of distal rings and annulets, SMNH X 1685, × 250. □ G. Longitudinal section of septum, SMNH X 1023, × 200.

rings. Density of lirae 5–6 per 0.1 mm proximally and 7–8 per 0.1 mm distally.

Proximal septal region: septa well developed, the most distal one occurring at an outer conch diameter of 0.40–0.45 mm. Total number of septa in mature specimens unknown but, judging from the thick accumulation of mural parts, the number should at least exceed 10. Septa are 0.40–0.55 mm apart, free parts perpendicular to long axis. Those most proximal septa always with straight and very thin free parts. Distal parts of septal region with free parts of septa proximally having straight laminae but increasingly concave septa. Thickness of septa 0.05–0.09 mm. Mural parts of proximal septa very long while on the distal septa they taper out rapidly. Mural parts symmetrical.

Living chamber symmetrical with proximal end rounded or blunt. Chamber gently expanding in a distal direction. Internal wall surface smooth along the proximal half of the living chamber but gradually irregular in the distal half. Inner wall surface reflecting roughly the external surface of the wall; undulation caused by well developed annular shelves located proximally to the crests of the rings.

Pseudopuncta unknown. Thickness of primary shell 0.02 mm proximally, 0.05–0.07 mm distally. Wall considerably thickened proximally by thick accumulations on mural parts of septa. Total thickness in this region 0.10–0.15 mm.

Remarks. – *Seretites? cataractae* occasionally shows some variation in density of the rings in the extreme proximal part of the conch. There may be up to 20–22 per mm. The shape of the distal rings varies somewhat towards being more symmetrical and wider at the base.

Having three ring patterns distinguishes this species from all others on Gotland. Separately, the various ring patterns resemble those in other *Seretites?* species, i.e. *S. exilis* and *S.? versabilis*. The distal ring pattern shows similarities with the ring pattern of *Tentaculites limatulus* but the latter species has wider interspaces and more annulets per interspace.

Occurrence. – *Seretites? cataractae* ranges from the lower part of the Upper Visby Beds up to the upper part of the Högklint Beds, unit *b*. In the section at Vattenfallsprofilen 1, it occurs between 1.5 and 22.5 m a.s.l. It is sparse in the Upper Visby Beds but abundant in the two lowermost units, *a* and *b*, of the Högklint Beds. It is not yet known outside Gotland.

Seretites? exilis n. sp.

Fig. 25

Derivation of name. – Latin *exilis*, thin, slender, referring to the thin development of the rings and the generally slender conch.

Holotype. – SMNH No. X 1589, Fig. 25A.

Type stratum. – Upper Visby Beds, 1.0–1.90 m a.s.l. in the section at Vattenfallsprofilen 1.

Type locality. – Vattenfallsprofilen 1, Gotland.

Material. – From the type locality 10 specimens; from localities in the Lower Visby Beds 37 specimens, from the Upper Visby Beds 40 specimens and from the Högklint Beds, unit *a*, 2 specimens.

Diagnosis. – Straight, slender, medium-sized *Seretites?* species, expanding proximal part at 4–5°, distal part subcylindrical. Annulation of three types. Proximal part with equally spaced rings, succeeded distally by asymmetrical, slim and high rings separated by one annulet in each interspace. Distal part with sequences of the latter type of annulation alternating with others having weakly developed rings separated by interspaces with 3 or 4 annulets. Lirae. Proximal part internally with straight, regularly spaced, thin septa. Internal wall surface of living chamber smooth proximally, gently undulating distally. Pseudopuncta unknown.

Table 3. Seretites? exilis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	PA
SMNH X 1589 (holotype)	6.30	0.55	0.32	
SMNH X 1026	5.13	0.63	0.50	
SMNH X 1030	2.15	0.34	0.22	4°
SMNH X 1031	2.00	0.38	0.25	4.5°
SMNH X 1032	5.62	0.50	0.33	

Description. – Conical, slender conch, proximal part expanding at 4–5°, distal part subcylindrical. Estimated length 12–13 mm. Minimum outer proximal diameter 0.09 mm. Outer distal diameter 0.65 mm. Initial chamber unknown. Aperture perpendicular to long axis.

Surface of conch annulated in three principal modes; proximal part with rings of equal size and spacing, occasionally every other ring slightly larger in size. More distally, two alternating ring patterns. One pattern of asymmetrical, narrow and high rings with orthocline axial trace and convexo-concave profile. Rings spaced 0.09–0.12 mm apart proximally and 0.16–0.20 mm distally (measured at an outer conch diameter of 0.24–0.36 mm and 0.50–0.65 mm, respectively). Interspaces slightly concave or flat with one, sometimes two or three, regular annulets. Annulets distinctly prosocyrt and pointed, height: basal width 1.5: 1. This type of annulation extend for a length of 2.0–2.5 mm. Second type of distal annulation comprises more widely spaced, low rings with low crests, separated by interspaces with 5–7 annulets. Spacing of rings between 0.25–0.40 mm. The two distal ring patterns have no fixed positions on the conch, but vary considerably.

Well developed lirae in each tertiary interspace, crossing annulets but not rings. Density of lirae 15–20 per 0.1 mm.

Proximal septal region: septa thin, straight,regularly spaced at intervals of 0.17–0.20 mm. Total number unknown but minimum 8. Last septum at an outer diameter of 0.25–0.30 mm. Free parts of septa perpendicular to long axis. Their thickness 0.005–0.007 mm. Mural parts thin and extend, overlapping one another, for a considerable distance in the conch.

Living chamber subcylindrical with a blunt proximal end. Internal wall surface rather smooth proximally, more irregular distally as the mural parts of the last septa taper.

Primary shell thin, having a proximal thickness of 0.005–0.01 mm, distal thickness 0.012–0.015 mm. Total

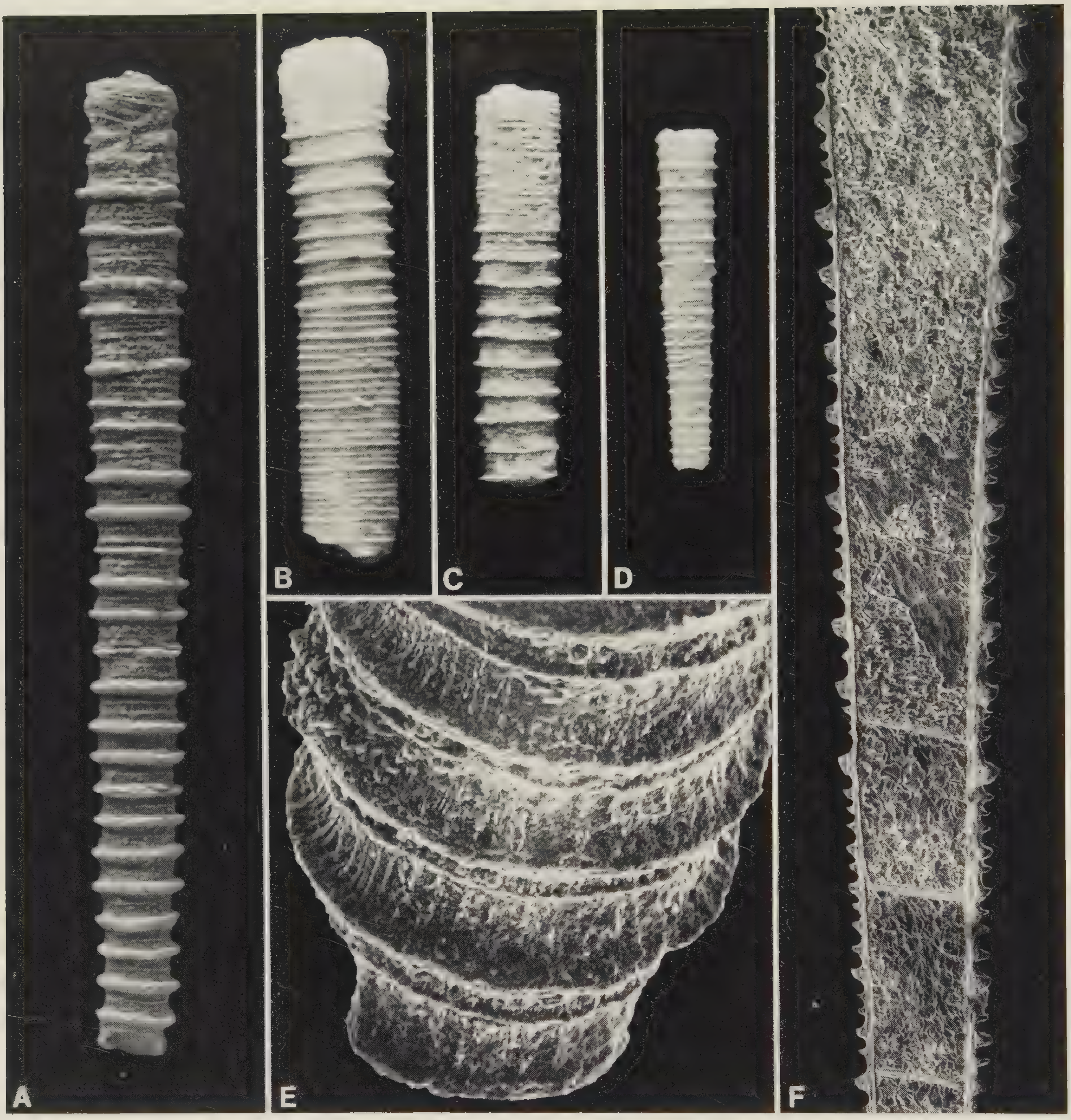


Fig. 25. Seretites? exilis n. sp. ☐ A. Holotype, SMNH X 1589, × 25; Vattenfallsprofilen 1, 1.70–1.90 m. ☐ B. Specimen showing adult ring pattern, SMNH X 1029, × 25; Gnisvärd 1, MS 175. ☐ C. A different distal ring pattern, SMNH X 1028, × 25; sample as for B. ☐ D. Specimen showing juvenile ring pattern, SMNH X 1030; × 25; Nyhamn 1, MS 176. ☐ E. Oblique apertural view of distal primary rings and annulets, SMNH X 1033, × 250; Ireviken 2, G 74-47 KL. ☐ F. Longitudinal section of distal septal region and early adult part, SMNH X 1034, × 125; sample as for E.

thickness of proximal wall increased by mural parts of septa to 0.018–0.020 mm. Pseudopuncta unknown.

Remarks. – The material is fragmentary which makes a study of variation somewhat difficult. However, some variation in the length of the various annulation patterns as well as their alternation may be observed.

The annulation pattern of *Seretites? exilis* shows similarities to *S.? cataractae,* but the former species may be distinguished by the more irregular occurrence of the ring patterns, the sharper relief and higher density of the rings. Internally, the septa of *S.? exilis* are much thinner than those of *S.? cataractae.* The difference in size of the two species is also significant.

Occurrence. – *Seretites? exilis* is sparse in the Lower and Upper Visby Beds. A few specimens questionably referred to this species have come from the basal parts of the Högklint Beds, unit *a.* The species has not so far been found outside Gotland.

Seretites? versabilis n. sp.
Figs. 17A–B, 18C, 26.

Derivation of name. – Latin *versabilis,* changeable, referring to the regular change in the proximal part between rings and annulets.

Holotype: SGU type collection, Fig. 26A.

Type stratum. – Slite Beds, Slite Marl.

Type locality. – Follingbo 10, Gotland.

Material. – From the type locality 7 specimens, from additional localities 45 specimens.

Diagnosis. – Straight, narrow, proximal part expanding at 4–5.5°, distal part slightly less. Ornament in proximal part perpendicular to long axis. Early distal part with regularly spaced rings separated mostly by one annulet in each interspace. Distal ring pattern of more widely spaced rings separated by interspaces with 2–4 annulets, most distally rings in pairs, well spaced apart. Rings asymmetrical, convexo-concave and compartively low. Proximal part divided internally by well spaced, thin septa, perpendicular or occasionally slightly oblique to long axis. Living chamber slightly conical with obtuse proximal end. Internal wall surface smooth. Conch wall without pseudopuncta.

Description. – Conch narrow, proximal part expanding at 4–5°, distal part slightly less. Change from proximal to distal growth angle gradual. Conch straight, medium-sized, estimated length in mature specimens 14–16 mm. Initial chamber unknown. Minimum outer proximal diameter 0.10 mm. Aperture perpendicular to long axis. Outer distal diameter in mature specimens normally 0.95–1.10 mm.

External ornament of two principal ring patterns. Proximal part and distal part up to an outer conch diameter of ca. 0.90 mm with regular alternating rings and annulets. Most interspaces with only one annulet especially in the region immediately before the distal ring pattern. Most proximal interspaces with two or even three annulets. Spacing and size of rings increasing gradually in a distal direction, density 4–5 rings per mm. Rings slightly asymmetrical with orthocline or prosocline, slightly prosocyrt, axial traces. Profile of rings convexo-concave. Hinge lines distinct forming the crestal lines of the rings. Annulets coarse with wide bases, cuspate or slightly convexo-concave in profile. Distinction of rings from annulets occasionally difficult because of the large size of the latter.

Distal ring pattern of more widely spaced and larger rings. Most distal rings commonly grouped in pairs, density 3 rings per mm. Spacing of rings rather variable, commonly between 0.35–0.50 mm. Rings separated by interspaces with 2–4 regularly spaced annulets. Distal rings distinctly asymmetrical with prosocline and prosocyrt axial traces, profile convexo-concave with sharp hinge lines distal to the gently rounded crests. Rings comparatively low, 0.07–0.08 mm, height: basal width 1: 2.0–2.5.

Table 4. Seretites? versabilis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
Holotype	12.52	0.92	0.14		4.5°
SGU Te 19	11.48	0.92	0.16		5°
SGU Te 20	15.12	0.96	0.16		5.5°
SGU Te 22	9.56	0.88	0.16		4.5°
SGU Te 24	12.60	0.88	0.24		4.5°
SGU Te 25	15.20	0.92	0.14		4.5°
SMNH X 1595	6.85	0.63	0.10	0.36	5°
SMNH X 1597	3.52	0.59	0.24	0.32	4.5°

Annulets of distal part similar to those proximally.

Interspaces either flat or concave, the latter especially in the tertiary interspaces.

Whole conch covered by well developed lirae crossing annulets, but not occurring on the slopes of the rings, density 5–6 per 0.1 mm length.

Proximal septal region; septa well spaced at intervals of 0.15–0.35 mm, last septum at an outer conch diameter of 0.30–0.36 mm. Free parts of septa generally perpendicular to long axis, occasionally slightly oblique, thin, 0.01 mm. That same thickness is maintained in the mural parts which extend distally for a considerble distance. Mural parts clearly overlap one another, not only the next septum but several.

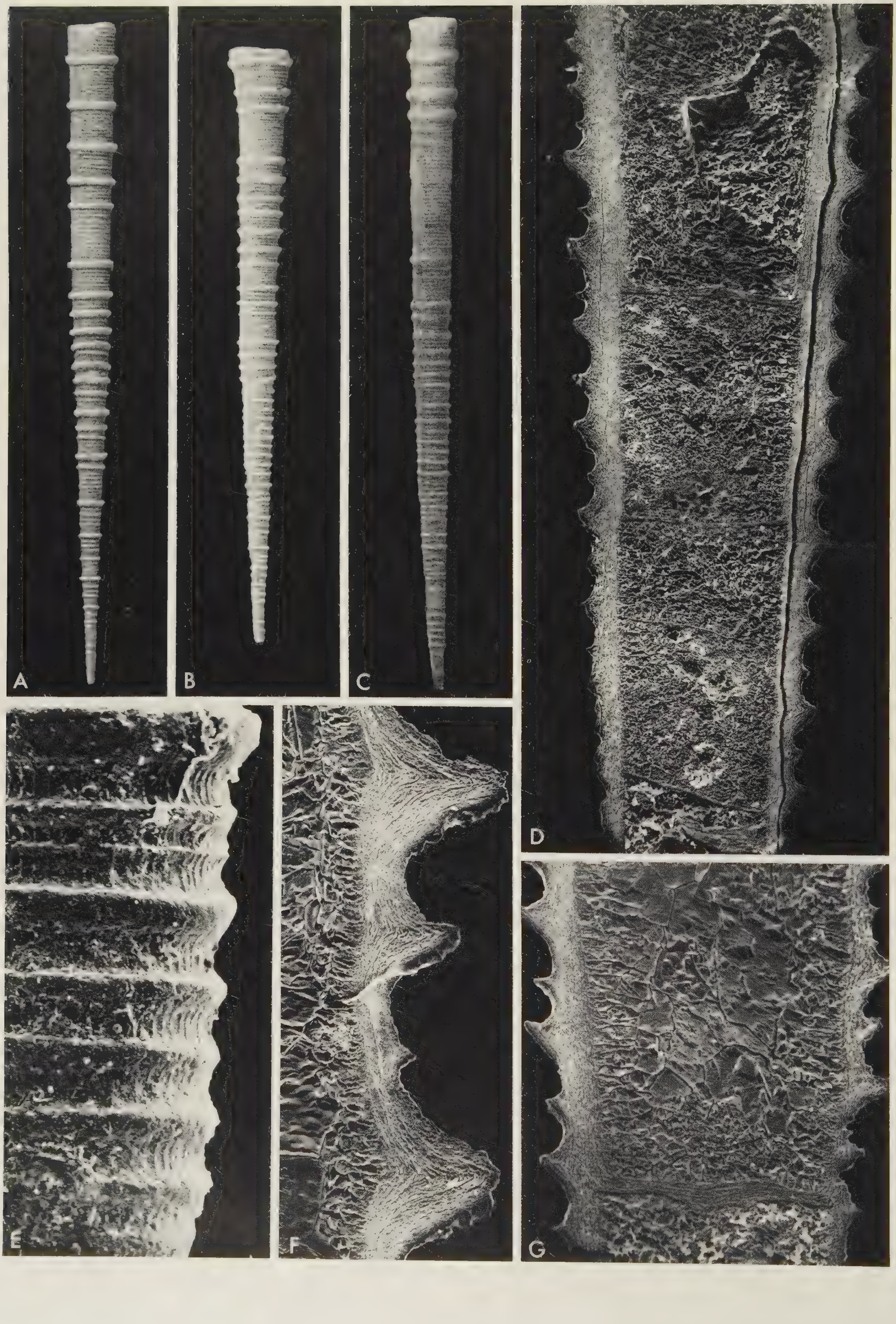
Living chamber conical or subcylindrical most distally, proximal end obtuse. Internal wall surface smooth with only minute annular concavities at the rings.

Pseudopuncta unknown. Thickness of primary shell 0.02–0.03 mm proximally and slightly more, 0.04–0.05 distally. Total thickness of the proximal conch wall increased 3–4 times by the mural parts of the septa.

Remarks. – *Seretites? versabilis* shows some variability which could occasionally complicate identification. Variation occurs mainly in the distal part of the conch where rings differ in size, shape and spacing. Occasionally this produces a ring pattern either resembling that of *Dicricoconus clintianus* or *Dicricoconus acutalis.* The ring pattern of the proximal part may also vary, to have more widely spaced rings than normal and more annulets per interspace. Distally, the bi-annulate ring pattern and the very wide interspaces are characteristic of the species.

The features of *Seretites? versabilis* seem to agree fairly well with those in some species of *Seretites* Ljashenko. For example, *Seretites ivanensis* (Ljashenko 1969a, Pl. 9: 4–5) develops the same type of distal ring pattern. Besides, oblique septa are characteristic of *Seretites.* Provinsionally, the Gotland species described is designated *Seretites? versabilis.*

Occurrence. – Confidently determined specimens of *Seretites? versabilis* have only been found at localities in the Slite Marl, northwestern part and in undifferentiated levels. The species is relatively rare at the localities. It has not been observed outside Gotland.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Genus *Tentaculites* von Schlotheim 1820

Type species (designated subsequently by Zagora 1969). – *Tentaculites scalaris* von Schlotheim 1820; from a Silurian erratic boulder, Oberwiederstädt, Germany.

Species in Scania and Gotland. – *Tentaculites gothemensis* n. sp., *T. hisingeri* n. sp., *T. limatulus* n. sp., *T. liquis* n. sp., *T. loxus* n. sp., *T. obstipus* n. sp., *T. scalaris* von Schlotheim.

Diagnosis (emended). – Medium to large in size, 10–40 mm, genus of the family Tentaculitidae. Conical conch, proximal part expanding at 6–13°, distal part at 1–5° or becoming subcylindrical. Conch straight except for the proximal part which exhibits some degree of curvature. Initial chamber conical, passing gradually into the juvenile part. Width of the distal conch 1.5–2 mm, occasionally up to 3 mm. Exterior with prominent primary rings perpendicular to oblique to long axis and increasing gradually in size and spacing towards the distal end. Regular, distinct annulets in interspaces and on distal slopes of rings. Lirae. Interior of conch divided proximally by septa, in the most proximal part mostly free, distally endoconic. Occasionally, all septa endoconic, densely packed. Living chamber long, conical or subcylindrical with a distinctly conical proximal end. Internal wall surface clearly undulating along most of the living chamber because of well developed annular shelves in the rings, distal to their crests. Pseudopuncta occasionally developed.

Stratigraphical and geographical distribution. – The type species, *T. scalaris,* occurs in Downtonian and Podlasian Beds of the Baltic area. Other species of the genus occur in Wenlockian-Ludlovian and up to the Frasnian-Famennian boundary (Lardeux 1969). Reports of the genus in the Ordovician are dubious (cf. Lardeux 1969:31). The genus is cosmopolitan.

Remarks. – The generic designation of *Tentaculites* was settled finally by Zagora (1969) who re-discovered and re-described von Schlotheim's (1820) species *T. scalaris* and designated a lectotype (Pl. 3: 3) from among von Schlotheim's original material (1820, Pl. 29: 9). Undoubtedly, the lack of a proper designation and description of the "type genus" for the entire order Tentaculitida caused much of the disorder evident for such a long time in the tentaculitoid literature. Unfortunately, the lectotype is very poorly preserved (cf. Zagora 1969: 223). However, the additional material figured, except for the specimen in Pl. 2:1 which probably belongs to another species, is convincing and illustrates well the significant generic characters. My additional material of *Tentaculites scalaris* from the Ohesaare Beds of Estonia confirms this. The diagnosis above is extended compared with that given by Zagora (1969: 223) to include significant internal characters.

It is not possible to review all species referred in literature to this genus, as was explained earlier. Lardeux (1969: 31) lists 27 species but the generic assignment of several is questionable. I agree with Lardeux that revision is necessary to show the true generic affinity. This applies particularly to many species from the Silurian and Devonian of Great Britain and North America.

Tentaculites gothemensis n. sp.

Fig. 27

Derivation of name. – Latin *Gothemensis,* from the parish of Gothem which includes the type locality.

Holotype. – SMNH No. X 1140, Fig. 27B.

Type strata. – Halla Beds, unit *c* (sample G 72–104a KL).

Type locality. – Gothemshammar 1, Gotland.

Material. – From the type locality, 40 specimens. From other localities, 13 specimens.

Diagnosis. – Medium-sized *Tentaculites* with slightly curved proximal part. Proximal growth angle 7–10°, distal growth angle 2–3°. Distal annulation of distinct rings, occasionally in cycles of 4 or 5 rings and separated by interspaces with few annulets. Primary interspaces sloping inwards. Living chamber conical, in its proximal part distinctly asymmetrical and pointed, distally with a strongly irregular wall surface which has annular prosocline shelves. Weak pseudopuncta.

Description. – Conch slender, proximal part expanding at 7–10°, distal part at 2–3°. Proximal conch slightly curved, in some specimens distinctly curved. Distal part straight. Estimated full length of adult specimens 11–12 mm. Initial chamber unknown. Minimum outer proximal diameter ca. 0.10 mm. Aperture perpendicular to long axis. Outer distal diameter normally 0.90–0.95 mm.

Conch ornamented with rings and annulets, normally perpendicular to long axis but occasionally slightly oblique, especially in juvenile part. Annulation of extreme juvenile part of small rings which increase gradually in size and spacing distally. Density of rings 15–16 per mm in early proximal part, 7–9 per mm more distally. Interspaces in distal juvenile part frequently each having one annulet. This ring pattern continuing into the early adult part of the conch but with gradually wider interspaces and larger rings. Distal part of conch with equally spaced rings, with a density of 3 rings per mm. Indistinct cyclic pattern developed occasionally, each cycle having 4–5 rings. This weak cyclic pattern shown merely by the increased size at intervals of one ring followed by a somewhat wider interspace than normal.

Fig. 26. Seretites? versabilis n. sp. ☐ A. Holotype, SGU type collection, × 10. ☐ B. SGU type collection, × 10. ☐ A, B – Follingbo 10, unnumbered SGU sample. ☐ C. SGU type collection, × 10; Follingbo 9, unnumbered SGU sample. ☐ D. Longitudinal section of septal region, SMNH X 1597, × 125; Follingbo 2, MS 420. ☐ E. Detail of juvenile part, SMNH X 1596, × 100; same sample as for D. ☐ F, G. Longitudinal section of distal conch wall, × 250, and last septum, × 175, SMNH X 1667; Follingbo 1, MS 435.

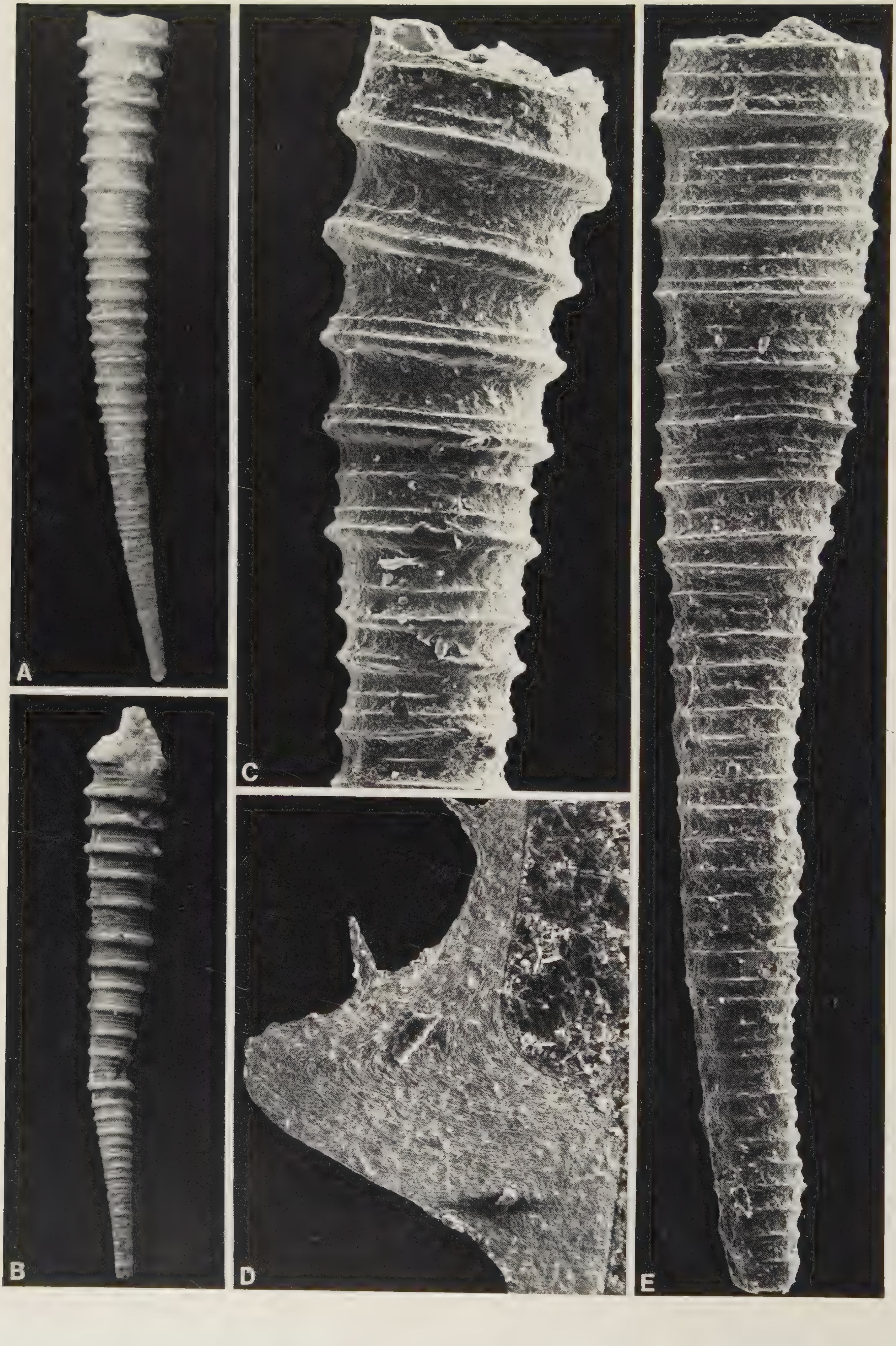
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Table 5. *Tentaculites gothemensis* n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1140 (holotype)	6.93	0.83	0.23		8°
SMNH X 1141	7.92	0.95	0.16		7°
SMNH X 1145	7.64	0.95	0.27	0.42	8°
SMNH X 1146	8.12	0.95		0.20	10°
SMNH X 1147	9.54		0.14	0.47	9°
SMNH X 1154	7.52		0.20		7°
SMNH X 1156	7.56	0.92	0.12		7.5°
SMNH X 1159	8.71	0.83	0.16		7°

Rings in juvenile part almost symmetrical with wide bases and low, gently rounded crests. Rings in adult part clearly asymmetrical, orthocline or faintly prosocline, axial traces orthocline and prosocyrt, rings slightly convexo-concave in profile. Proximal slopes of rings steep, sometimes becoming almost perpendicular to long axis of the conch, distal slopes generally passing into the succeeding interspace without any marked boundary. Height of distal rings 0.10–0.15 mm on their proximal sides, 0.05–0.06 mm on their distal slopes, height: basal width 1: 1.5–1.6.

Annulets absent from the most proximal juvenile part but present more distally, one per interspace, adult part generally with 3–5 per interspace. Annulets distinctly prosocline, especially at distal end commonly attaining a height of 0.04–0.06 mm. Rings narrow with a pointed profile.

Proximal interspaces concave and narrow, distally widening gradually to about twice the basal width of the rings. Interspaces sloping inwards to long axis of conch at angles of 5–10°.

Whole conch ornamented by minute indistinct lirae at a density of 20 lirae per 0.1 mm.

Proximal septal region: septa numerous, mostly grouped into a massive endoconic structure. Endocones generally extending ca. 2 mm with the last septum at a conch diameter of ca. 0.45–0.50 mm, strongly asymmetrical, with their mural parts at angles of 10–25° to long axis. Septa at extreme proximal end normal with straight or slightly concave free parts and symmetrical mural parts, spaced at 0.25–0.50 mm with a thickness of ca. 0.05 mm.

Living chamber long and distinctly conical. Proximal part asymmetrical. Inner wall surface of living chamber strongly irregular because of well defined annular concavities. Accumulation of lamellae greatest on the inner part of the proximal limbs of the rings to form distinct, prosocline annular shelves.

Pseudopuncta developed weakly in proximal limbs of rings. Thickness of primary shell increasing gradually from 0.04 mm proximally to 0.07 mm distally.

Fig. 27. *Tentaculites gothemensis* n. sp. Gothemshammar 1, G 72–104 KL. □ A. Almost complete specimen, SMNH X 1159, ×15. □ B. Holotype, SMNH X 1140, ×15. □ C. Specimen showing early adult part, SMNH X 1152, ×75. □ D. Longitudinal section of distal primary ring, SMNH X 1151, ×300. □ E. Specimen showing juvenile and early adult parts, SMNH X 1153, ×75.

Remarks. – The morphological characters of *Tentaculites gothemensis* show limited variation. There may be some differences in the ring pattern, occasionally tending towards a cyclic arrangement of the rings. The number and position of the annulets may show some variation, especially in the proximal part. Some specimens may have a single annulet in the proximal part of each interspace.

The distal part of the conch of *Tentaculites gothemensis* resembles that of *Tractabilopsis serratus*, having similar, inward sloping interspaces. However, the latter species has much more distinctly convexo-concave rings, more annulets per interspace and more distinct lirae. The juvenile parts of the two species are very dissimilar.

Occurrence. – *Tentaculites gothemensis* is comparatively rare and only low numbers have been found at the type locality in the Halla Beds, unit *c*. Some finds at a few other localities suggest that the species may extend up into the lower part of the Klinteberg Beds.

Tentaculites hisingeri n. sp.

Figs. 12D, 28.

Derivation of name. – Latin *hisingeri*, in honour of Wilhelm Hisinger, Swedish naturalist and geologist, 1766–1852, who gave the first brief description and illustration of the species.

Synonymy. – □ *Tentaculites annulatus* Hisinger–Hisinger, 1837b, Pl. 35: 2. □ *T. scalaris* – Zagora 1969, Pl. 2: 1.

Holotype. – SMNH No. Mo. 4766, Fig. 28A, figured in Hisinger 1837b, Pl. 35: 2.

Type stratum. – Burgsvik Beds, upper part.

Type locality. – Hoburgen, Gotland.

Material. – Gotland: from the Eke Beds 21 specimens, from the Burgsvik Beds 45 specimens and from the Hamra Beds 66 specimens. Scania: 98 specimens from the Öved-Ramsåsa Beds, unit *1*.

Diagnosis. – Large-sized *Tentaculites* expanding in proximal part at 8–12°, in distal part at 3–5°. Conch straight, except in juvenile part with a clear curvature. Initial chamber conical. Annulation prominent, proximally with gradually denser rings, distally with asymmetrical rings. Rings of equal height and width separated proximally by concave interspaces, distally by flat, distinctly inwards sloping interspaces. Annulets prominent, proximally 1 or 2 per interspace, distally 6–10. Pseudopuncta well developed.

Description. – Conch proximally expanding at a growth angle of 8–12° except for its most proximal extreme which is more or less subcylindrical. Distal part of conch expanding at a growth angle of 3–5°, change in growth

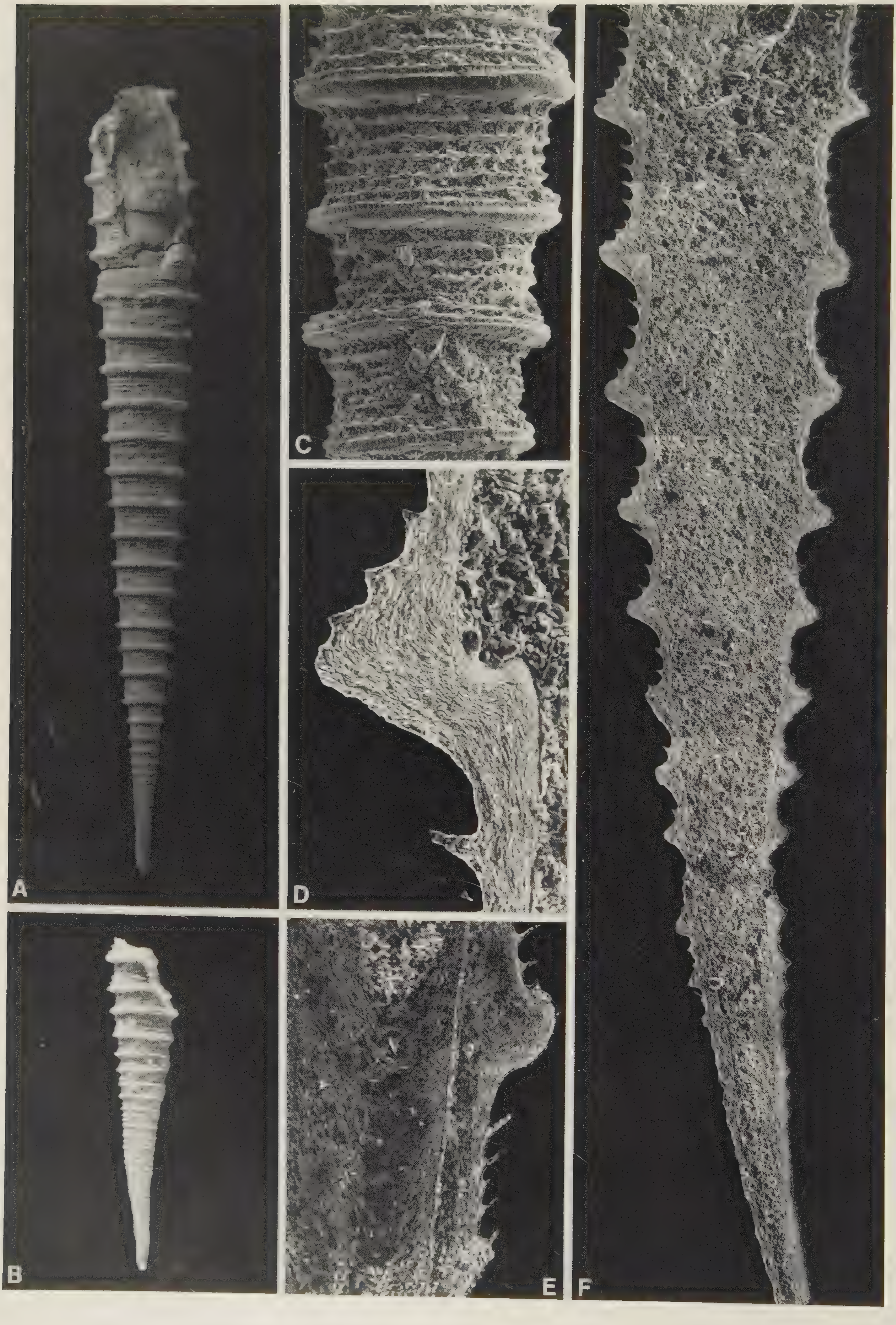
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Table 6. Tentaculites hisingeri n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	PA
SMNH Mo. 4766 (holotype)	14.20	1.85	0.13	0.40		10°
SMNH X 1434	6.53		0.18	0.40		10°
SMNH X 1436	12.69	1.88	0.40		0.85	8°
SMNH X 1437	16.71	2.06	0.22		0.96	8°
SMNH X 1438	15.13	1.77	0.33	0.51		9°
SMNH X 1439	12.91	1.84	0.26		0.66	9°
SMNH X 1440	8.41	1.25	0.15	0.40		8°
SMNH X 1443	3.46	0.70	0.14	0.31	0.59	10°
SMNH X 1452	21.07		0.20	0.51		8°
SMNH X 1453	13.46	1.74	0.10	0.51		11°
SMNH X 1454	13.54	1.66	0.28	0.55	0.87	11°
LR 2	20.20	2.10	0.16	0.51		10°
LR 3	17.90	2.14	0.07	0.48	1.14	12°

angle rather gradual, in many specimens more rapid at a conch diameter of about 0.50–0.60 mm, i.e. in the part of the conch where the distal ring pattern begins. Conch straight except for the most proximal part, which frequently has distinct curvature. Conch large, fully mature specimens attaining a length of 20–22 mm. Outer distal diameter 2.0–2.20 mm, outer proximal diameter immediately behind initial chamber about 0.06–0.08 mm. Initial chamber conical, passing directly into the proximal, juvenile part without any detectable constriction or other feature to distinguish it from the rest of the conch.

Annulation of two ring patterns, rings and annulets perpendicular to long axis. Proximal part with low rings passing gradually to distinct primary rings in the distal part of the conch. The transition mostly occurring at a conch diameter of about 0.40–0.50 mm, occasionally already at a conch diameter of 0.25–0.30 mm. Juvenile rings increasing gradually in size and spacing, at a density from 14 to 16 rings per mm. Primary rings of the distal part initially increasing rapidly in size and spacing, but soon attaining rather constant spacing and size, total number of rings in fully adult specimens up to 30, ring density 4 per mm proximally and 2 per mm distally. Primary rings from 0.45–0.50 mm apart proximally and 0.80–1.20 mm distally.

First 2 or 3 primary rings symmetrical and bi-convex in profile with gently rounded crests. Rings towards distal end, more asymmetrical. Axial traces of early asymmetrical rings rather straight and opisthocline, towards the distal end with the internal parts more steeply inclined distally as the annual shelves become more prosocline. Proximal slopes of rings distinctly convex and smooth, distal slopes slightly concave or straight and have coarse annulets superimposed. Hinge lines very distinct, in early adult part coinciding with ring crests, but towards the distal end becoming more distal and crests rounded. Height of proximal rings 0.04–0.06 mm, height of distal rings 0.20–0.25 mm, height: basal width 1: 1.

Primary interspaces and distal slopes of rings with regularly spaced annulets. Number varying, generally 1 or 2 in the earliest primary interspaces, 6–10 in those most distal. Spacing of annulets about 0.04 mm proximally and 0.08 mm distally. Annulets prosocline and straight, occasionally opisthocyrt, especially in the distal part of very large specimens. Height of annulets varying from 0.12 to, distally, 0.20 mm.

Primary interspaces concave proximally, but become gradually flatter towards the distal end and slope inwards to long axis. Distal inclination occasionally 10–12°.

Lirae present along the whole conch, occupying the tertiary interspaces, but never the proximal slopes of the rings. Lirae in the crestal furrow of each ring particularly significant. Density of lirae 5–6 per 0.1 mm.

Proximal septal region: septa free or, most commonly, endoconic; asymmetrical and with variable lengths of mural parts distally. Mural parts always shorter towards concave side of specimens with distinctly curved proximal parts and also steeper on this side than on the convex side. Last septum formed at an outer conch diameter of 0.85–1.00 mm, exceptionally at a diameter of up to 1.15 mm. Mural parts of endocones conical and commonly at angles of 18–25° to long axis, distal endocones generally narrower than those proximally. Free parts narrow, especially in the most distal septal region where endocones are most evident. Portion with true endocones extending occasionally 1.5–3.0 mm but some specimens possess a fully endoconic septal development from the earliest juvenile part. Proximal septa mostly with clearly concave and narrow free parts, frequently 0.05–0.07 mm wide. Free parts 0.30–0.40 mm apart.

Living chamber distinctly conical, especially in its proximal part, internal wall surface strongly irregular because of incompletely filled annular concavities. Shape of concavities determined by the annular shelves of the rings: initial part of living chamber with prosocline and gently rounded shelves, progressively becoming orthocline then opisthocline towards the distal end. Latter attitude conspicuous in large specimens where innermost part of annular shelve extends 0.10–0.12 mm distal to the crest of the ring, causing very deep and narrow, opisthocline annular concavities occasionally.

Proximal limbs of rings with distinct pseudopuncta, best developed in the outermost laminae. Tubercles forming pseudopuncta become levelled out gradually and only penetrate half or slightly more of the limbs.

Thickness of primary shell uniform, proximally 0.02–0.03 mm thick, distally 0.04–0.06 mm. In the most distal part of the living chamber, the secondary shell forms annular deposits over the annular shelves and the portions immediately proximal to them. Annular deposits increasing rapidly in thickness and attaining their maximum on the internal part of the annular shelves, resulting in slight constriction of the internal diameter of the body chamber at the levels of rings.

Fig. 28. Tentaculites hisingeri n. sp. B, C, D, F. Kättelviken 4, MS 778; E. Bjärsjölagård 2, Bj 71-3 KL. ☐ A. Holotype, SMNH Mo. 4766, ×10; "Hoburgen", Hisinger collection (SMNH). ☐ B. Specimen showing juvenile part and initial chamber, SMNH X 1444, ×25; ☐ C. Early proximal part, SMNH X 1457, ×60. ☐ D, F. Longitudinal sections of distal primary ring, ×300, and juvenile and adult parts, ×60, SMNH X 1456. ☐ E. Longitudinal section of endoconic septa and conch wall, SMNH X 1455, ×75.

Remarks. – The material of *T. hisingeri* studied shows some variation in morphological characters such as the level where adult annulation begins, the number of annulets per primary interspace and, particularly, in the development of septa. However, the features characterizing the species are the regular annulation, the narrow and comparatively low rings and the straight, inward sloping interspaces. These features distinguish *T. hisingeri* from the closely related *T. scalaris* which has rings that are higher, particularly in the early distal part, wider and separated by shorter primary interspaces. In the latter species, the number of annulets per interspace is also generally less. In the youngest beds of unit *1b* (Zone *3* of Eichstädt) at Klinta, there are specimens resembling *T. hisingeri* which have somewhat higher proximal rings and narrower interspaces. This material is not good enough to decide whether the specimens should be regarded as morphological varieties of *T. hisingeri* or if they constitute early representatives of the closely related *T. scalaris* which appears at the base of unit *3* of the Öved-Ramsåsa Beds. The general ring pattern and septal arrangement of *T. hisingeri* show similarities to *T. obstipus*. However, the latter species is characterized by oblique rings, a feature never seen in *T. hisingeri*, and by smaller size. The ring pattern of *T. hisingeri* is to some extent similar to that of *T. ornatus* Sowerby, but the latter is much slenderer, has a tendency to form bi-annulate rings and has a completely different septal arrangement.

When Hisinger (1837b) figured and briefly described the species, then as *Tentaculites annulatus*, he seems to have regarded it as new. No author's name follows the specific name in contrast to all other fossil names given in that paper. The description is very brief and only states some characters in very broad terms which, in fact, could be valid for any tentacultid species. The only reference by Hisinger to von Schlotheim's species *T. annulatus* was made in his note (1840:113) of von Schlotheim's opinion on the zoological affinity of the tentaculitids. The taxonomic status of *T. annulatus* von Schlotheim has already been discussed in an earlier chapter (p. 5).

Occurrence. – *T. hisingeri* makes its first appearance in the middle to upper Eke Beds and disappears at the top of the Hamra Beds. It is a rather characteristic species for the uppermost Burgsvik Sandstone and in the lowermost Hamra Beds. In Scania it occurs in the uppermost part of unit *1a* and in the entire unit *1b* of the Öved-Ramsåsa Beds.

Tentaculites limatulus n. sp.
Fig. 29.

Derivation of name. – Latin *limatulus*, somewhat filed, smoothed, referring to the low relief of the proximal annulation.

Holotype. – SMNH No. X 1035, Fig. 29A.

Type stratum. – Högklint Beds, unit *b* (sample G 73–66 KL).

Table 7. Tentaculites limatulus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	PA
SMNH X 1035 (holotype)	15.80	1.05	0.19	0.60		5.5°
SMNH X 1036	13.70		0.22	0.60		5.0°
SMNH X 1037	4.20	0.55	0.16	0.55		4.5°
SMNH X 1041	4.30	1.05	0.50	0.73	0.68	
SMNH X 1043	12.20	1.12	0.13			
SMNH X 1044	14.30	1.25	0.18			5.0°
SMNH X 1045	11.60	1.10	0.25		0.62	4.5°
SMNH X 1047	5.10	0.73	0.40		0.55	

Type locality. – Svarven 1, Gotland.

Material. – From the type locality 60 specimens, from additional localities 11 specimens.

Diagnosis. – Medium-sized, straight *Tentaculites* with a proximal growth angle of 5–6°. Proximal annulation with conspicuously low relief, occasionally slightly oblique at the transition to the distal pattern. Interspaces with numerous annulets. Pseudopuncta.

Description. – Conch straight, slender, proximal part expanding at 5–6°, distal part subcylindrical. Conch medium-sized, normally 14–16 mm long. Initial chamber not certainly found. Minimum outer proximal diameter 0.05 mm, maximum outer distal diameter 1.25 mm. Aperture perpendicular to long axis.

Surface of conch exhibiting two types of annulations: proximal annulation of very low, equally spaced, gently rounded rings separated by indistinct shallow interspaces approximately as wide as the rings. In longitudinal section, the wall appears to undulate slightly. Annulation frequently somewhat oblique to long axis near the transition to the adult part of the conch. Adult annulation begins at an outer conch diameter of 0.55–0.60 mm with rings of one size gradually increasing in size and spacing towards the distal end. Distance between rings from 0.30–0.35 mm proximally and 0.65–0.80 mm distally, density of rings at distal end 2 per mm measured at an outer diameter of 1.0–1.2 mm. Rings comparatively high, with a height: basal width of 1.5–2.0: 1. Rings may or may not be symmetrical, and have an orthocline to opisthocline attitude, axial traces either straight or prosocyrt, profile of rings varying from bi-convex to faintly convexo-concave. Crests gently rounded.

Primary interspaces with annulets, proximally 2 or 3 per interspace, distally 6–10. Annulets low, irregular in shape and often in spacing, sometimes extending into the lower third of the distal slopes of the rings. Primary interspaces flat or slightly concave, having a width 2–3 times the width of the rings, tertiary interspaces occupied by faint lirae. The material available unfortunately does not allow their detailed examination.

Proximal septal region; septa, the last at an outer conch diameter of 0.55–0.68 mm, in most of specimens sectioned steeply inclined in the distal part of the septal region to form endoconic structures. Endocones occa-

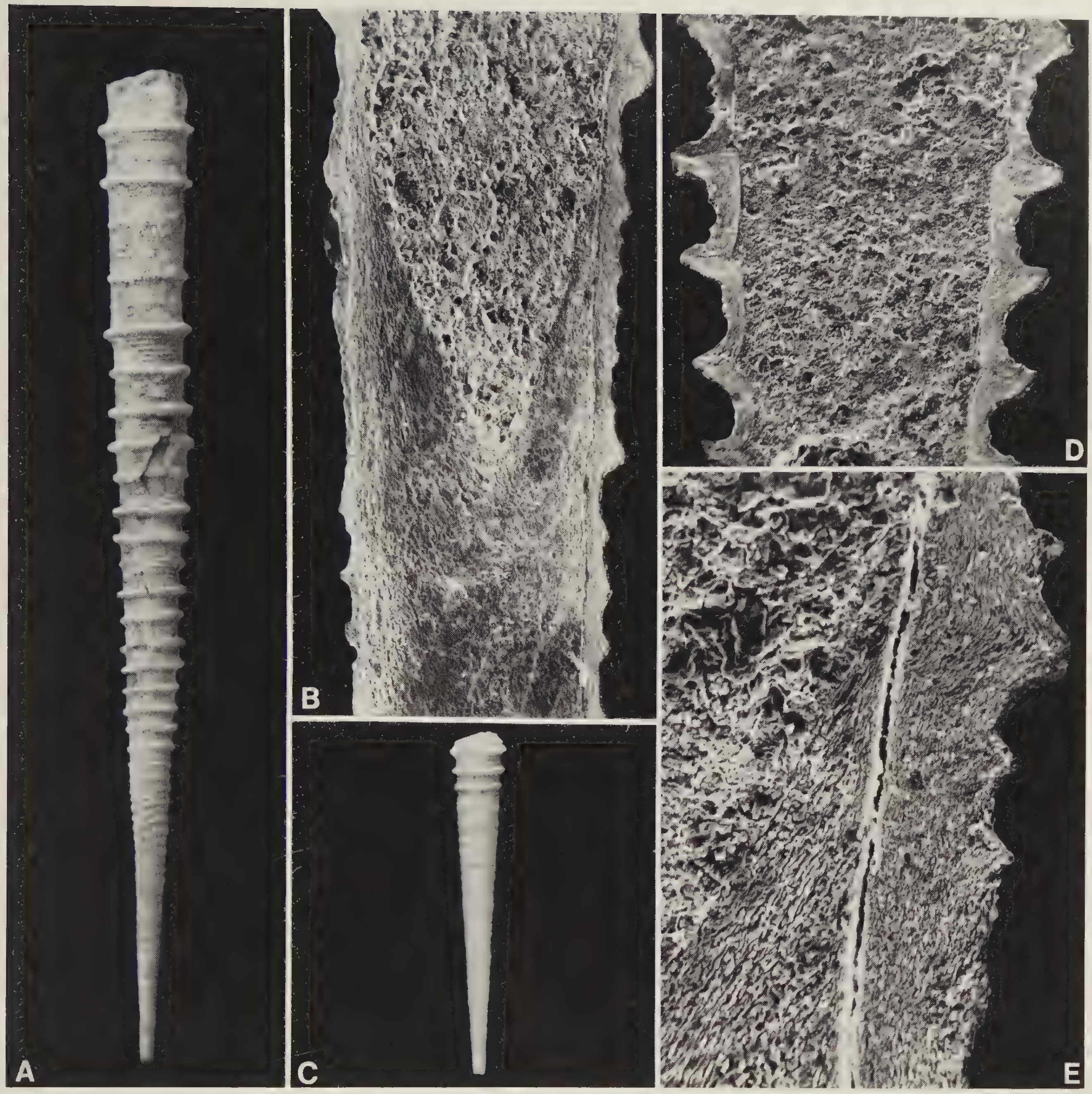


Fig. 29. Tentaculites limatulus n. sp. A, B, E. Svarven 1, G 73-66 KL. C, D. Svarven 1, MS 709. ☐ A. Holotype, SMNH X 1035, × 10. ☐ B, E. Longitudinal section of distal septal region, × 75, and detail of contact of septa and primary shell, × 300, SMNH X 1041. ☐ C. Specimen showing juvenile part, SMNH X 1037, × 12.5. ☐ D. Longitudinal section of adult part, SMNH X 1042, × 75.

sionally extending for 1.6–2.0 mm, asymmetrical with apices of the cones variable in position in relation to long axis of conch. Some specimens with endocones followed directly by a common free septum. Distances between free septa increase gradually, from 0.15 to 0.50 mm in specimens without endocones. Free parts of septa concave, symmetrical and perpendicular to long axis, thickness 0.02–0.03 mm. Mural parts extending comparatively far distally and attached discordantly to the conch wall at angles of 10–15°. Their distal parts increasing progressively in thickness by addition of new laminae, often resulting in internal constriction of the juvenile part, at maximum ca. 1.5–2.0 mm before the last formed septum. Length of accretion zone generally 1.6–2.0 mm.

Living chamber long, subcylindrical with proximal end rounded or pointed, internal wall surface undulating moderately proximally, conspicuously irregular distally because of prominent, deep annular concavities. The latter rather symmetrical and more or less reflecting the external shape of the ring. Asymmetrical concavities occur occasionally, with annular shelves somewhat distal to the rest of the rings.

Primary shell frequently with weak pseudopuncta in proximal limbs of rings. Thickness fairly uniform along conch, only increasing gradually from 0.02–0.03 mm proximally to 0.05–0.06 mm distally.

Remarks. – Some variation in the position of the first well-developed ring has been observed. Normally the transition between the juvenile and adult stages occurs at a conch diameter of 0.55–0.60 mm, but in some specimens the transition occurs around either 0.75 mm or 0.25–0.30 mm. The variable development of the septa has been described previously. Probably the different positions of the last septum reflect only various ontogenetic stages of the conchs.

Tentaculites limatulus may be distinguished from all other species by the conspicuous juvenile ring pattern. The adult ring pattern may sometimes resemble that of *Tentaculites liquis,* especially when the latter shows some obliquity of the rings. However, *T. limatulus* differs from *T. liquis* in having denser rings, larger numbers of annulets in each interspace and in the development of the septa.

Occurrence. – *Tentaculites limatulus* is restricted to the Högklint Beds, units *b* and *c*. A fragmentary specimen resembling *T. limatulus* appears one metre below the Upper Visby–Högklint boundary, but it cannot definitely be referred to this species. In the range-chart it is therefore designated as *T.* cf. *limatulus.*

Tentaculites liquis n. sp.

Fig. 30

Derivation of name. – Latin *liquis,* sloping, oblique, referring to the oblique annulation.

Holotype. – SMNH No. X 1048, Fig. 30A.

Type stratum. – Högklint Beds, unit *b* (sample G 74–49 KL).

Type locality. – Horsan 1, Gotland.

Material. – From the type locality more than 50 specimens, from additional localities more than 250 specimens.

Diagnosis. – Slender *Tentaculites* species of medium size, proximal part expanding at 3–4.5°, distally subcylindrical. Annulation prominent with rings of one size, oblique to long axis. Interspace concave with few annulets. Weak pseudopuncta.

Description. – Conch straight, occasionally slightly curved in proximal part, slender with a proximal growth angle of 3.0–4.5° and distally subcylindrical. Conch medium-sized, average length of adult specimens 13–14 mm. Initial chamber of conch conical and narrow with an outer distal diameter of 0.03–0.04 mm, aperture in mature specimens perpendicular or slightly oblique to long axis, outer distal diameter normally 1.0–1.10 mm.

Table 8. Tentaculites liquis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	TNRI	PA
SMNH X 1048 (holotype)	10.38	1.02	0.15		35	4.5°
SMNH X 1049	10.57	0.95	0.15		44	4.5°
SMNH X 1050	7.88	0.73	0.09	0.31	40	4°
SMNH X 1051	8.50	0.80	0.08	0.28	38	4°
SMNH X 1052	8.95	0.86	0.14	0.31	34	3°
SMNH X 1053	12.28	0.99	0.14		44	5°
SMNH X 1056	5.46	0.58	0.10	0.30	31	5°
SMNH X 1057	5.35	0.53	0.14	0.29		5°
SMNH X 1586	6.89	0.65	0.16	0.28	32	5.5°

External surface of conch covered by rings of one size, oblique with an annular slope of 3–10°, occasionally up to 17°. Obliquity most pronounced in juvenile and early adult parts of conch. Holotype exhibiting abrupt change of oblique pattern, however, more common is a pattern of similarly sloping rings along the whole conch. Rings increasing gradually in size and spacing towards distal end, density in juvenile part 7–8 rings per mm proximally and 4–6 per mm distally (measured at outer conch diameters of 0.25 m and 0.65 mm, respectively). Distance between rings close to the aperture in mature specimens frequently almost twice that previously. Rings clearly asymmetrical, orthocline or prosocline in attitude with prosocyrt axial traces, profile convexo-concave profile generally more common. Height: basal width approximately 1: 1 in both juvenile and adult parts of the conch.

Primary interspaces with regularly spaced and few annulets, generally 1–3, per interspace. Annulets low and triangular in cross-section, proximal part of conch often without annulets. Interspaces distinctly concave, particularly proximally.

Lirae present in tertiary interspaces. Unfortunately, the material available does not permit their closer examination because of unfavourable preservation.

Proximal septal region with numerous, regularly spaced septa, the last occurring at a conch diameter of 0.28–0.31 mm. Free parts perpendicular to long axis or, more commonly, inclined with the same slope as the annulation. Free parts of septa thin, 0.008–0.010 mm most proximally, distally attaining thicknesses of 0.015–0.025 mm. Free parts normally straight, occasionally slightly concave, mural parts symmetrical and long, with the last septum commonly up to 1.75 mm long. Last four or five septa commonly exhibit an accretion zone for a distance of 1.75–2.25 mm. Last septum often with a narrow, rounded free part.

Living chamber elongate and straight, with an asymmetrical, rounded proximal end and a subcylindrical distal part, internal wall surface slightly irregular proximally, but more irregular distally because of poorly filled annular concavities. Proximal concavities symmetrical, more or less reflecting the external shape of rings, distal concavities asymmetrical with annular shelves distal to the crest of the rings.

Proximal limbs of rings occasionally weakly developed pseudopuncta. Thickness of shell uniform, gently increasing from 0.020–0.025 mm proximally to 0.045–0.050 mm distally.

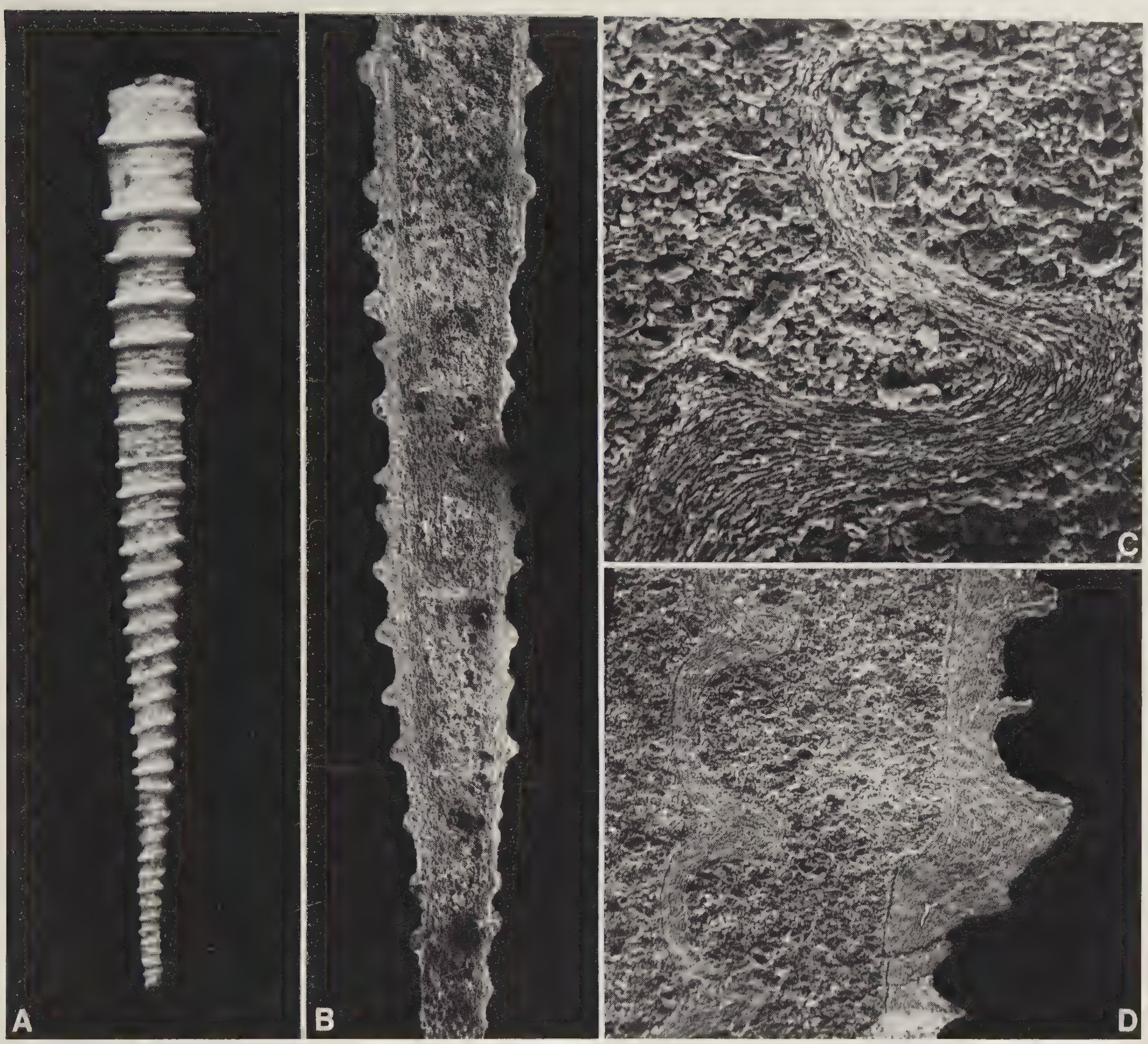


Fig. 30. Tentaculites liquis n. sp. ☐ A. Holotype, SMNH X 1048, × 12.5; Horsan 1, G 74-49 KL. ☐ B. Longitudinal section of juvenile part, SMNH X 1588, × 75; Släthällar 2, G 74-73 KL. ☐ C, D. Longitudinal sections of primary ring close to aperture, × 100, and early distal conch wall, × 150. In D, note the young specimen inside the conch. SMNH X 1059; "Hunstäde", unnumbered SMNH sample.

Remarks. – The oblique ring pattern is variable, either with the annular slope maintained the same along the whole conch, or changing once or more. The juvenile part may vary slightly, being either straight or slightly curved. Internally, some variation occurs in the inclination of the free parts of the septa.

Tentaculites liquis is generally easily distinguished from other species in the Högklint Beds. For comparison of *T. liquis* with *T. limatulus* see the description of the latter. The oblique annulation resembles that seen in the Ludlow species *Tentaculites obstipus*. However, the latter species differs in having more symmetrical and rounded rings, flatter distal interspaces, and strongly concave and short proximal interspaces. The third species with an oblique ring pattern, *Tentaculites loxus,* shows many features similar to the other two species, but it differs from *T. liquis* in having higher and more distinct rings.

Occurrence. – *Tentaculites liquis* is characteristic of the middle part of the Högklint Beds. It has been observed only in unit *b* and in beds still undifferentiated but tentatively placed in the lower–middle part of the Högklint Beds (Lauterhornsvik 1, Släthällar 2 and 3). The species has not been recorded outside Gotland.

Tentaculites loxus n. sp.
Fig. 31.

Derivation of name. – Greek *loxos,* oblique, referring to the oblique annulation.

Holotype. – LO 4882 T, Fig. 31A.

Type strata. – Öved-Ramsåsa Beds, unit *3* (*sensu* Grönwall 1897).

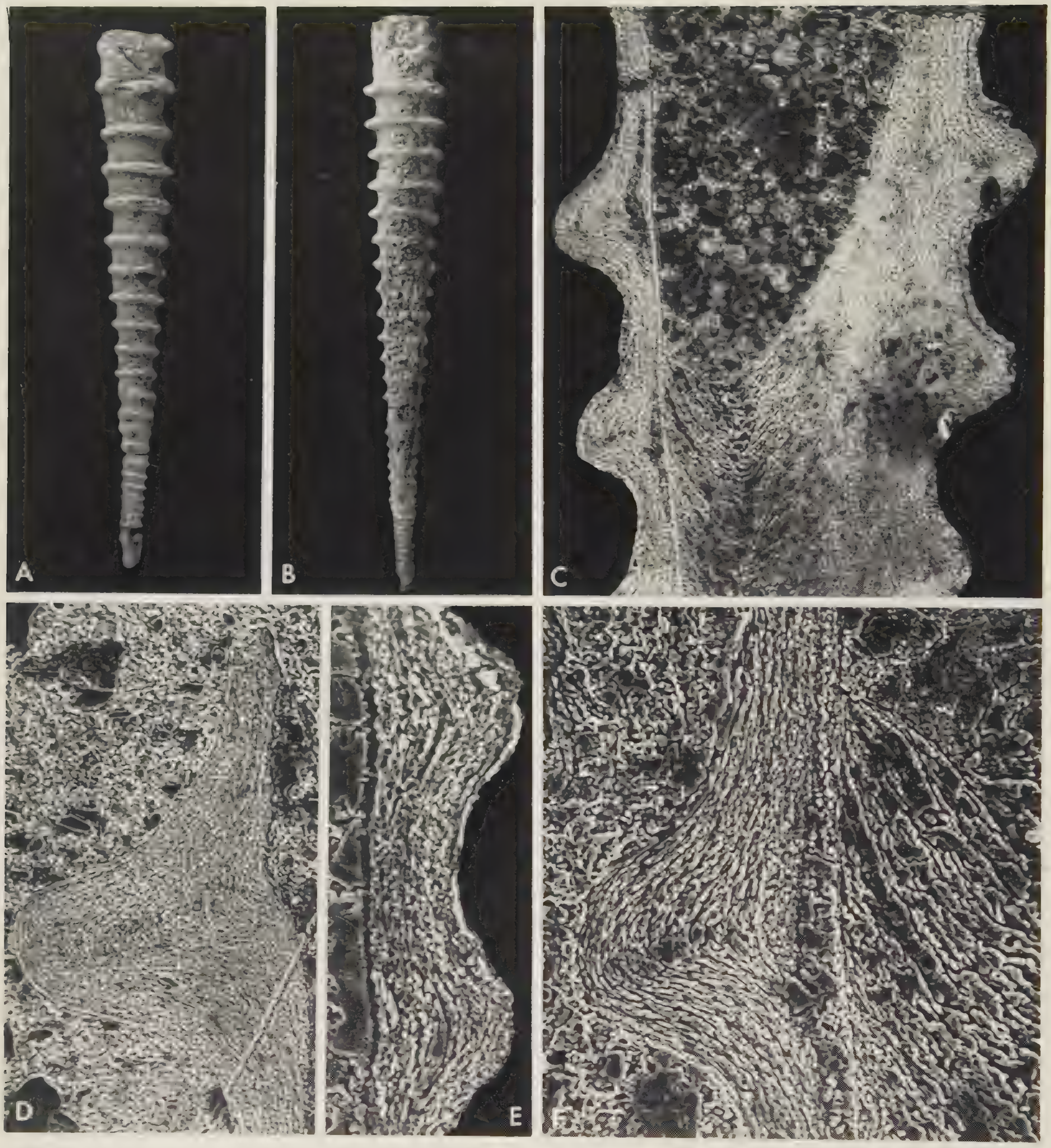


Fig. 31. Tentaculites loxus n. sp. A, B – Ramsåsa 10, unnumbered PDL sample. C, D, E, F. Ramsåsa 10, Ra H 66-1 LJ: ☐ A. Holotype, LO 4882T, × 10. ☐ B. LO 4883t, × 20. ☐ C, D, F. Longitudinal sections of distal septal region, × 100, primary ring close to aperture, × 150, and detail of septal attachment to primary shell, × 200, SMNH X 1639. ☐ E. Longitudinal section of juvenile rings, SMNH X 1640, × 300.

Type locality. – Ramsåsa 10, Scania.

Material. – From the type locality 17 specimens, from additional localities 2 specimens.

Diagnosis. – Medium-sized, slender, straight *Tentaculites*, proximal part expanding at 5–5.5°, distal part at 2–3°. Annulation oblique, annular slopes 3–15°. Primary rings well defined, high, with rounded crests. Annulets in the

Table 9. Tentaculites loxus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
LO 4882 T (holotype)	8.00	0.88	0.24		5°
LO 4883 t	8.92	1.00	0.20		5°
LO 4884 t	9.04		0.24	0.28	5.5°
SMNH X 1613	9.76	0.92	0.16	0.44	5°
SMNH X 1640	7.40	0.88	0.18	0.46	

comparatively wide interspaces numerous. Proximal part with massive, slightly asymmetrical endoconic septa. Weakly developed pseudopuncta.

Description. – Slender conch, proximal part expanding at 5–5.5°, distal part at 2–3°. Conch straight and of medium size, estimated full length 10–11 mm. Initial chamber unknown. Minimum outer proximal diameter 0.16 mm, outer distal diameter 1.0 mm, aperture oblique to long axis, obliquity gradually decreasing as conch grows.

Conch ornamented with regularly spaced primary rings, increasing in size and spacing towards the distal end. Rings 0.40–0.50 mm apart, distally separated by wide interspaces with numerous annulets. Annulation significantly oblique, generally ith steeper annular slopes proximally than distally, annular slope 13–15° proximally, distally 3–6°. Annulation with low, symmetrical rings most proximally, increasing gradually distally in size and spacing. Distal rings with wide bases, height: basal width, 1: 3.

Primary rings slightly asymmetrical with prosocline attitude, occasionally almost symmetrical, axial traces slightly opisthocline or orthocline appearing either straight or prosocyrt. Axial traces commonly vanishing towards the outermost part of rings where laminae become hemispherical. Profile of rings slightly bi-convex with gently rounded crests. Slopes commonly approaching a plane shape. No hinge line formed. Slopes of primary rings smooth. Highest rings are distal and rise ca. 0.2 mm above the interspaces, height: basal width 1: 1.1–1.2.

Annulets in primary interspaces low and dense, increasing from 2 or 3 per interspace proximally to 7–10 distally. Because of poor preservation of the material their detailed morphology could not be examined; neither could lirae be observed. Interspaces concave, concavity decreasing slightly distally.

Proximal septal region filled with massive body of endoconic septa, last cones occurring at an outer conch diameter of about 0.45 mm in adult specimens. Endocones strongly asymmetrical, commonly with one side almost missing, apices of cones close to conch wall. Longest side of cones tapering rather rapidly and does not extend more than three rings.

Living chamber distinctly conical with an asymmetrical proximal part, internal wall surface irregular because of incompletely filled annular concavities, the latter asymmetrical and becoming gradually deeper towards aperture. Annular shelves shallow and generally prosocline.

Primary and secondary shells well separated by a thick inner organic layer. Weak pseudopuncta. Thickness of primary shell ca. 0.03–0.05 mm in the septal region and ca. 0.06 mm distally.

Remarks. – *Tentaculites loxus* is characterized by oblique and relatively high rings and wide interspaces. In specimens where the oblique annulation is weakly developed, the ring pattern resembles that seen in *Tentaculites scalaris.* However, it differs from the latter by having a much slenderer conch and more pointed rings. Besides, there is a marked difference in size.

The material of *Tentaculites loxus* available is not enough to permit study of the variation of morphological characters. However, it can be seen that the annular slope and the shape of the endoconic septa may vary.

Occurrence. – *Tentaculites loxus* is generally sparse and is restricted to the red beds of the Öved Ramsåsa Beds, at the top of unit *3* and the lower part of unit *4* (*sensu* Grönwall 1897).

Tentaculites obstipus n. sp.

Figs. 10E, 32.

Derivation of name. – Latin *obstipus,* oblique, referring to the oblique annulation.

Holotype. – SMNH No. X 1430, Fig. 32A.

Type strata. – Eke Beds, lower–middle part (unnumbered SMNH sample).

Type locality. – Sigdes 1, Gotland.

Material. – From the type locality 20 specimens, from additional localities in the Eke Beds 55 specimens and from the Burgsvik Beds 45 specimens. From the Öved-Ramsåsa Beds in Scania five specimens.

Diagnosis. – Medium-sized *Tentaculites,* proximal part expanding at an angle of 5.5–7°. Annulation conspicuously oblique with rings of one size, separated proximally by concave interspaces, distally by flat. Proximal part internally with septa, those proximally, free, and those distally, in densely packed, asymmetrical endocones. Pseudopuncta in the proximal limbs of the distal rings.

Description. – Conch slender, proximal part expanding at a growth angle of 5.5–7°, distal part at 1–2° or more or less subcylindrical. Change in growth angle occurs gradually but mainly just after the last septum in mature specimens. Conch straight except for its most proximal part which may be slightly curved. Maximum deflection of proximal point measured from a sagittal plane through the living chamber is ca. 0.25 mm. Conch medium-sized, estimated full at 14–15 mm. Initial chamber unknown. Minimum outer proximal diameter is 0.10 mm. Outer distal diameter 1.25–1.30 mm. Aperture slightly oblique to long axis.

Annulation composed of rings of one size alternating with annulets, clearly oblique to long axis, generally with an annular slope of 5–10° but occasionally up to 20°. Oblique ring pattern generally more conspicuous in proximal part decreasing distally. Rings increasing gradually in size and spacing towards distal end, density 5–6 rings per mm in the region of last septum, and 3 rings per mm close to aperture in adult specimens.

Proximal rings more or less symmetrical with gently

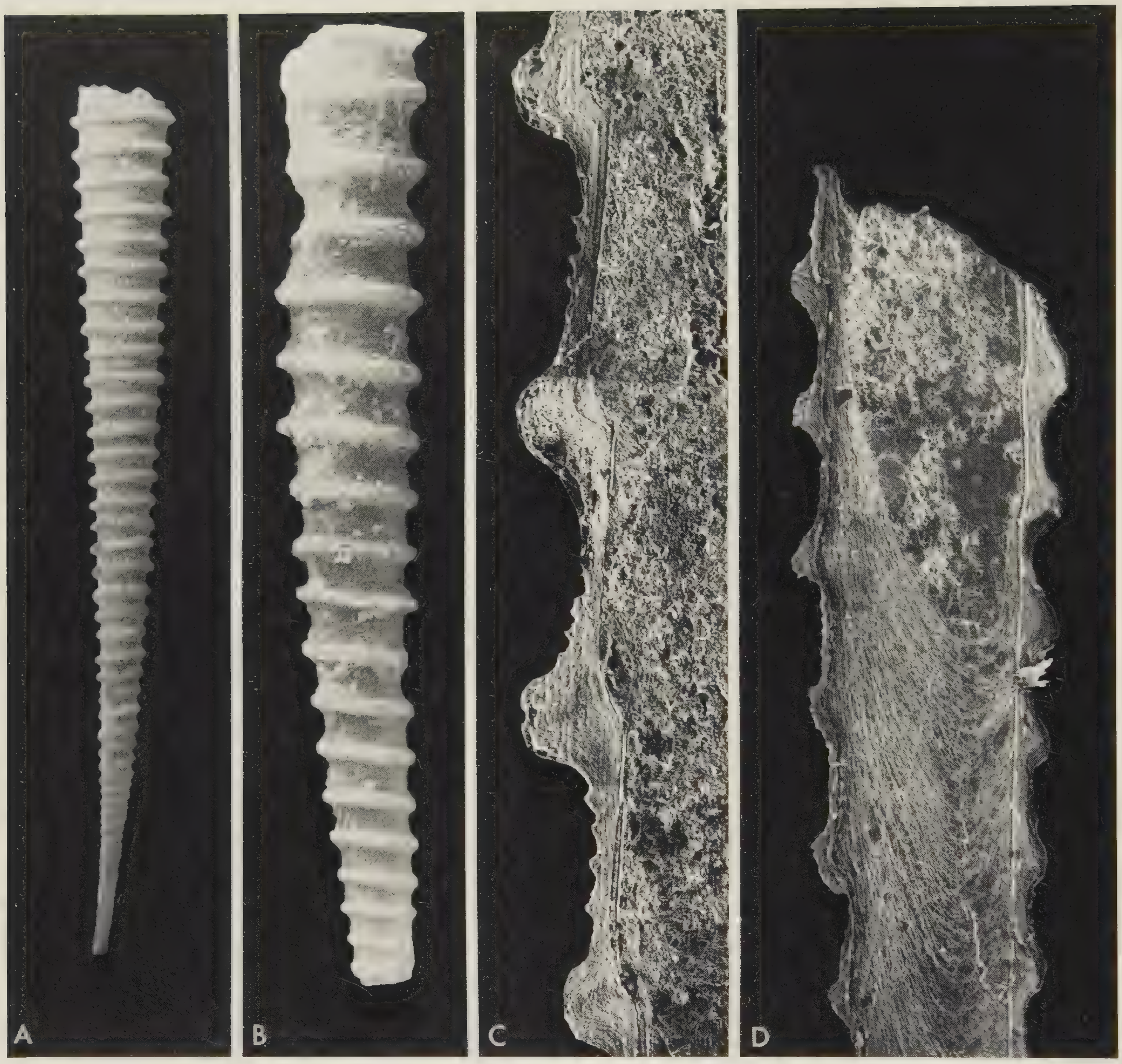


Fig. 32. Tentaculites obstipus n. sp. A. Sigdes 1, unnumbered SMNH sample. B–D. Kullunde 3, Got 76-31 SB. ☐ A. Holotype, SMNH X 1430, × 10. ☐ B. SMNH X 1433, × 10. ☐ C. Longitudinal section of distal conch wall, SMNH X 1423, × 75. D. Longitudinal section of septal region, SMNH X 1424, × 75.

rounded crests. Rings distinctly asymmetrical with opisthocline, straight axial traces in distal portion of the juvenile part and in adult part. Profile bi-convex with somewhat flattened crests, hinge line generally somewhat proximal crest. Proximal slopes steeper and longer than those distal which pass rather gently into succeeding interspaces. Height of distal rings 0.11–0.13 mm and height: basal width about 1: 2.

Tertiary interspaces with regularly spaced annulets, about 1 or 2 per interspace in proximal part and 4–6 per interspace distally, slopes of rings without annulets. Annulets low, slightly asymmetrical and with prosocline attitude. In the material available these rings have a triangular profile but it is likely that only the basal parts of these annulets remain, the fragile margins having been destroyed. Proximal interspaces concave, those distally with flatter centres.

Table 10. Tentaculites obstipus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1430 (holotype)	12.83	1.27	0.14		6°
SMNH X 1424	3.92	0.55	0.11	0.51	6°
SMNH X 1426	10.65	1.11	0.10	0.48	6°
SMNH X 1427	13.34		0.20		6.5°
SMNH X 1428	9.42	1.11	0.12	0.40	5.5°
SMNH X 1429	6.73	0.91	0.24	0.51	6.5°
SMNH X 1431	10.18		0.28		7°
SMNH X 1432	10.18	1.30	0.20		6.5°

Minute lirae present, at a distal density of 10–11 lirae per 0.1 mm. Unfortunately, the preservation of the material studied does not allow their satisfactory examination. Proximal septal region distally with septa forming densely packed endocones. Last septum develops at an outer conch diameter of ca. 0.5 mm, length of endocones 2.50–2.80 mm. Most proximal septal region with free septa, occasionally resembling endocones, free septa spaced 0.4–0.5 mm apart. Septa in the distal endoconic structure are strongly asymmetrical, the shortest mural parts being almost parallel to conch wall or sloping 5–10° to long axis. The longer mural parts are much more steeply inclined, up to 30° to long axis. Apices of endocones gently rounded, free parts of proximal septa with straight proximal sides but concave distal sides. Total number of these septa unknown.

Living chamber conical in its proximal part with an asymmetrical and gently rounded apex, more distally becoming less conical, almost subcylindrical. Internal wall surface distinctly irregular because of incompletely filled annular concavities, roughly reflecting the external shape of the rings. Annular concavities more asymmetrical and filled by secondary shell material mainly on the annular shelves in more mature specimens. Concavities never entirely filled, annular shelves narrow and prosocline.

Primary shell with pseudopuncta in the proximal limbs of the rings. Primary shell in septal region separated from septa by a distinct, thick organic layer, particularly well developed on the side of the conch where the mural parts of the septa are shortest. One of the sectioned specimens (SMNH No. X 1424), shows how this organic layer has been added on to the primary shell on a very smooth inner surface in which the rings are entirely filled (Fig. 32D). The secretion of this organic layer has continued during the formation of the septa. It can be seen to branch between the endocones at irregular intervals. A thick organic layer also separates the primary and secondary shells in the adult part of the conch (Fig. 32D). Thickness of primary shell 0.02–0.03 mm in the septal region, 0.03–0.04 mm distally.

Remarks. – The oblique ring pattern together with the pronounced endoconic development of the septa are characteristic features of *Tentaculites obstipus.* These features do not vary much. The variation observed is generally in the slope of the annualtion.

The species is distinguished from *Tentaculites liquis* by having wider rings, shorter and more concave proximal interspaces and the endoconic development of the septa. *Tentaculites obstipus* shows many similarities to *T. loxus* in general arrangement of the annulation and, particularly, in the septal arrangement. However, it differs from the latter by having lower rings and a different attitude of the rings. The interspaces of *Tentaculites obstipus* are somewhat wider than in *T. loxus.*

Occurrence. – *Tentaculites obstipus* is a common species in the Eke and Burgsvik Beds of Gotland. It ranges from low in the former beds to high in the latter. In Scania only a few specimens have been encountered, from the Öved-Ramsåsa Beds in the upper horizons of unit *1b* at Bjärsjölagård and from equivalent beds at Klinta.

Tentaculites scalaris von Schlotheim 1820

Figs. 8C, 10C–D, 12E, 13A, 33.

Synonymy. – ☐ *Tentaculites scalaris* n. sp. – von Schlotheim (1820:377, Pl. 29: 9b). ☐ *Tentaculites curvatus* n. sp. – Boll (1856: 324). ☐ *Tentaculites curvatus* Boll–Krause (1877: 28). ☐ *Tentaculites ornatus* Sowerby–Krause (1877: 28). ☐ *Tentaculites ornatus* Sowerby–Dewitz (1883: 80–86, Figs. 1–5). ☐ *Tentaculites annulatus* Schlotheim–Moberg & Grönwall (1909: 46–48, Pl. 2: 1). ☐ ?*Tentaculites annulatus* Schlotheim–Straw (1933: 125–126, Pl. 10: 1a–b, 2). ☐ *Tentaculites estonicus* n. sp. – Ljashenko (1958: 25, Pl. 5: 1). ☐ *Tentaculites scalaris* Schlotheim–Zagora (1969: 222–225, Pl. 1: 1–2, 2: 2, 3: 1–3). ☐ *Tentaculites scalaris* Schlotheim–Neben & Kreuger (1973, Pl. 107: 35).

Diagnosis (emended). – *Tentaculites* with a medium-sized conch, distal part straight, proximal part curved. Conch expanding in proximal part at 10–13°, distal part subcylindrical. Initial chamber conical. Annulation prominent with mostly perpendicular, occasionally oblique, rings. Rings gradually increasing in size and spacing towards aperture. Rings asymmetrical with ortho- or opisthocline attitude and convexo-concave profile. Annulets in the interspaces comparatively few, 1–3 proximally, 5–10 distally, asymmetrical and with prosocline attitude. Interspaces becoming inward sloping distally. Proximal part internally with well developed, asymmetrical, endoconic septa. Living chamber conical proximally, subcylindrical distally. Inner wall surface strongly irregular. Well developed pseudopuncta in the proximal and distal limbs of the rings, occasionally also in the interspaces.

Remarks. – The lectotype was figured and described by Zagora (1969: 222–225, Pl. 3: 3) from among von Schlotheim's (1820) original material from an erratic boulder designated *Beyrichia* Limestone. Zagora used together with material from the Ohesaare Beds of Estonia material from erratic boulders for his redescription of the species. von Schlotheim (1820) gave no information on the concomitant fauna. Zagora (1969: 224) lists some palaeocope ostracodes which indicate a position equivalent to the middle part of the Podlasian Beds in northern Poland. However, Zagora did not state whether this fauna came from the boulder of the lectotype or from additional material.

New morphological details have emerged from the present study. Therefore, the diagnosis of the species is emended compared to Zagora's (1969: 223). The following description is based on 60 specimens from Scania, three from Hoburgs Bank and ten from the Ohesaare Beds of Estonia.

The conch is conical, expanding in the proximal part at a growth angle of 10–13°, in the distal part at 2–4° or occasionally becoming subcylindrical. The major part of the conch is straight but the proximal part commonly show some curvature, with the apex displaced from a sagittal plane through the living chamber at most by 0.45–0.50 mm. The total length of the conch in fully adult specimens is 15–18 mm. The initial chamber is

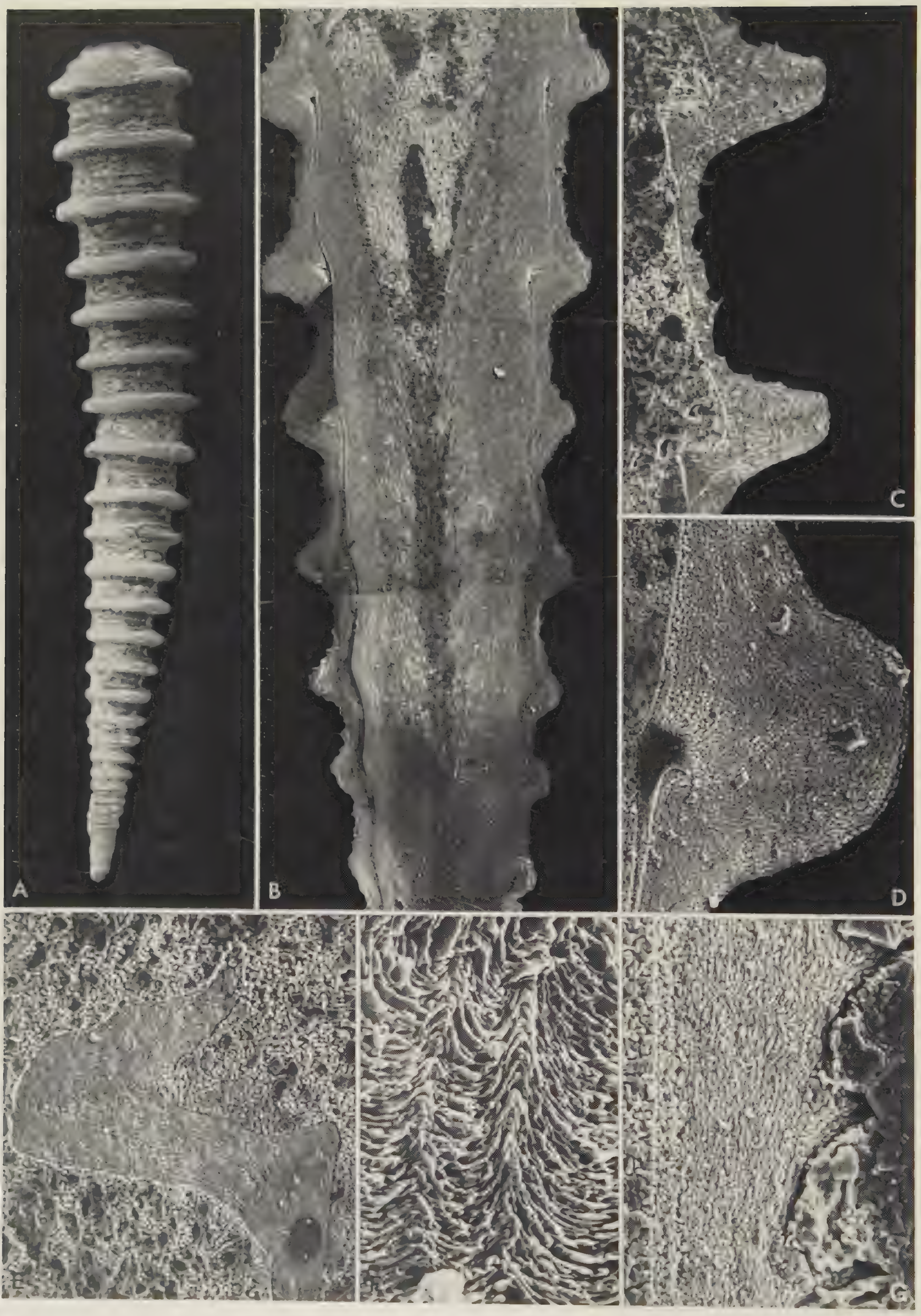

A
B
C
D
E
G

Table 11. Tentaculites scalaris von Schlotheim (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	PA
SMNH X 1645	10.20	1.32	0.24	0.44		11°
SMNH X 1646	8.20	1.32	0.20	0.40	0.46	13°
SMNH X 1647	9.72	1.24	0.28	0.50	0.60	11°
SMNH X 1650	7.72	1.14	0.20	0.40	0.46	10°
SMNH X 1651	11.44	1.64	0.52		0.80	
SMNH X 1656	9.12	1.44			0.54	12°
LR 4	9.11	1.39	0.20	0.47		12°

conical and the outer conch diameter behind it is ca. 0.10 mm. The aperture is perpendicular to the long axis and the maximum outer distal diameter in the Scanian material is 1.60–1.70 mm, in the Estonian material 2.20–3.10 mm.

The conch is ornamented with prominent rings which vary from perpendicular to strongly oblique to the long axis. Most proximally the rings are very low and of equal size and spacing. The first primary ring is at an outer conch diameter of 0.40–0.50 mm. The following primary rings increase gradually in size and spacing towards the distal end. The rings are spaced 0.15–0.25 mm apart proximally and spacing increases gradually to 0.90–1.40 mm distally. The primary interspaces have 1–3 annulets proximally and 5–10 distally.

The rings are asymmetrical with an ortho- or slightly opisthocline attitude. Commonly, the most proximal rings are less asymmetrical. The axial traces are slightly opisthocyrt or straight, but often disappears completely in the outermost part of the rings because of laminae become hemispherical. The profile of the rings is convexo-concave or bi-convex with rather diffuse hinge lines and gently rounded crests. The shape of the rings may vary to some extent even within a specimen. The proximal slopes are smooth, while the distal slopes in the distal part of the conch have 3 or 4 annulets. The distal rings reach a height of 0.20–0.25 mm and their height: basal width is 1: 1.5–2.0.

The annulets are clearly asymmetrical with a prosocline attitude. The proximal slopes pass gently into the tertiary interspaces, while the distal slope is short and steep, commonly perpendicular to the adjacent interspace. The primary interspaces are rather flat and slope in towards the long axis, particularly in the distal part of the conch.

Well developed lirae occur along the entire conch. Their density is 7–10 lirae per 0.1 mm.

The proximal septal region is divided by septa. Mainly they form densely packed endocones, particularly in the distal septal region. Most proximally, free, strongly conical septa may also occur. The endocones are asymmetrical. The lengths of the sides are variable and the apices of the cones are excentric. The last septum occurs at an outer conch diameter of 0.45–0.60 mm, exceptionally up to 0.80 mm.

Fig. 33. Tentaculites scalaris von Schlotheim. ☐ A. SMNH X 1645, × 15; Skartofta 1, Sk 76-1 KL. ☐ B, G. Longitudinal sections of septal region, × 60, and of early distal conch wall showing annulets and pseudopuncta, × 500, SMNH X 1660; Ohesaare Pank, Estonia, unnumbered SMNH sample. ☐ C, D, E, F. Longitudinal sections of adult conch wall, × 100, of juvenile primary ring, × 250, of primary ring forming the aperture, × 200, and detail of pseudopuncta in the proximal limb of the ring in E, × 2000, SMNH X 1652; Ramsåsa 2, Ra 71-3 KL.

The living chamber is initially strongly conical but gradually becomes subcylindrical in the most distal part. The conch wall behind the mural part of the last septum is strongly irregular, having well developed asymmetrical annular concavities and strongly opisthocline annular shelves. The chamber between rings largely reflects the inward sloping interspaces.

Well developed pseudopuncta appear particularly in the proximal limbs of the rings but also in the distal limbs and in the interspaces. The primary shell is separated well from the secondary shell by a thick inner organic layer. The thickness of the primary shell is 0.02–0.03 mm proximally and 0.04–0.05 mm distally.

Tentaculites scalaris von Schlotheim, particularly a small-sized individual, shows many similarities to *Tentaculites hisingeri* n. sp. However, the main features distinguishing the former species are: (1) denser rings proximally, more widely spaced rings distally, (2) occasionally the rings are oblique, (3) the rings are wider and higher, (4) the interspaces are more concave, (5) there are fewer annulets per interspace in the juvenile and early adult parts of the conch, (6) the proximal part is clearly curved, (7) the proximal growth angle is larger.

Occurrence. – The lectotype derives from an erratic boulder of "*Beyrichia*" Limestone found at Oberwiederstädt, DDR. The species has been reported from boreholes in northern Poland in the upper part of the Podlasian Stage (Hajłasz 1974), and also in Estonia in the Ohesaare Beds (Ljashenko 1958; this paper). In Scania it appears in unit *3* of the Öved-Ramsåsa Beds a few metres above the yellow sandstone, unit *2*, and extends up through to the very top of unit *4*. *Tentaculites scalaris* has been found in material from the offshore locality Hoburgs Bank in a sample labelled HBB:IV, together with *Nodibeyrichia tuberculata* (cf. Martinsson 1965b, 1967).

Genus *Tractabilopsis* n. gen.

Derivation of name. – Referring to the external similarity to *Tractabilis* Ljashenko, 1969.

Type species. – *Tractabilopsis serratus* n. sp.

Species. – Only the type species.

Diagnosis. – Medium-sized genus of Tentaculitidae with a proximal growth angle of 4.5–7° and a distal growth angle of 3–4°. Conch straight except for the proximal part which may show a slight curvature. Initial chamber unknown. Annulation proximally of regular, widely spaced rings, occasionally in cyclic arrangement with gradually increasing size and spacing of the rings. Rings separated by flat or slightly concave, long interspaces.

Distal part annulate with regularly spaced, strongly asymmetrical rings having steep proximal limbs and distal limbs passing gradually into interspaces strongly sloping inwards. Annulets abundant. Lirae distinct and widely separated. Proximal part divided internally by free septa. Living chamber long and conical with wall surface strongly irregular because of distinct, asymmetrical, deep and narrow annular concavities and strongly opisthocline annular shelves. Pseudopuncta unknown.

Stratigraphical and geographical distribution. – The only known species, *Tractabilopsis serratus* n. sp., is restricted both stratigraphically and geographically. It occurs in the Slite Marl immediately below the Ryssnäs Limestone on Fårö Island, northernmost Gotland.

Remarks. – *Tractabilopsis* n. gen. is characterized by the conspicuously inwards sloping attitude of the interspaces which becomes accentuated towards the distal end. The proximal annulation, of widely spaced rings which occasionally gradually become rhythmically arranged, is significant, as are the widely spaced lirae. Internally the deep and narrow, strongly asymmetrical annular concavities are characteristic. *Tractabilopsis* exhibits many similarities to the Devonian genus *Tractabilis* Ljashenko in the attitude of the distal interspace and the development of the annular concavities. However, *Tractabilopsis* differs externally by the rhythmical arrangement of some of the juvenile rings and the larger number of annulets in the interspaces which are reported to be almost smooth in *Tractabilis*. Internally no pseudopuncta have been observed in *Tractabilopsis* while these seem, according to the diagnosis, to be prominent in *Tractabilis*. Another difference, perhaps less important at generic level, is in the size of the two genera. *Tractabilis* is characterized in the diagnosis as large, up to 35 mm, while *Tractabilopsis* seldom exceeds 11 mm. The shape of the conch is somewhat different; *Tractabilopsis* has a larger proximal angle and a more conical shape of the living chamber.

Tractabilopsis serratus n. sp.

Figs. 19E, 34.

Derivation of name. – Latin *serratus,* toothed like a saw, referring to the profile of the conch.

Holotype. – SMNH No. X 1112, Fig. 34A.

Type stratum. – Slite Beds, *Slite Marl,* top (sample G 73-9 KL).

Type locality. – Sudersandsviken 1, Gotland.

Material. – From the type locality 30 specimens, from additional localities 40 specimens.

Diagnosis. – As for the genus.

Description. – Conical, narrow conch expanding proximally at 4.5–7°, distally at 3–4°. Conch straight but occasionally with slightly curved extreme proximal part. Conch of medium size, 10–11 mm. No initial chamber observed. Minimum outer proximal diameters 0.12 mm. Outer distal diameter of mature conchs 1.0–1.25 mm. Aperture perpendicular to long axis.

Table 12. Tractabilopsis serratus n. sp. (dimensions in mm)

Spec. No.	DEEC	ODID	OPRD	ODLS	TNRI	PA
SMNH X 1112 (holotype)	10.60	1.23	0.20		22	6°
SMNH X 1113	7.25	0.91	0.16		16	5.5°
SMNH X 1115	10.69	1.11	0.24	0.48	25	7°
SMNH X 1116	8.44	0.95	0.25	0.45	18	7°
SMNH X 1117	6.93	0.91	0.18	0.40	12	5°
SMNH X 1120	7.13	0.79	0.18	0.38	13	5.5°
SMNH X 1121	8.95	1.07	0.16	0.44	18	4.5°
SMNH X 1122	9.62	0.99	0.24	0.48	19	6°
SMNH X 1123	8.32	0.91	0.14	0.44	16	5°

Surface of conch ornamented with transverse annulation perpendicular to long axis. Two modes of proximal annulation: in the early juvenile part regularly spaced, equally sized rings, in the later part weak cyclic pattern of rings. Each cycle comprises 2 or 3 rings which gradually increase distally in size. Last ring of each cycle of same order magnitude as rings in adult part. Rings in the distal portion of each cycle occasionally closely assembled, but some specimens with just widely spaced rings separated by a few annulets. Ring density in juvenile part 2–3 per mm. Juvenile rings project distinctly from the surface of the conch, shape symmetrical or slightly asymmetrical with convex proximal limbs. Distal limbs shorter and passing fairly rapidly into the succeeding interspace.

Rings of the adult part of one size, regularly spaced at distances of 0.50–0.60 mm. Ring density 2 per mm along most of the adult part.

Adult rings strongly asymmetrical with the proximal limb almost perpendicular to the surface of the preceding interspace. Distal limb passing more gradually into the succeeding interspace or may be at a fairly high angle to it, especially early in the adult part. Proximal limbs considerably longer than the distal limbs. Axial trace of rings prosocyrt. Profile of rings convexo-concave with rounded, sometimes slightly flattened, crests. Most distal rings in mature specimens have a height from the limb of ca. 0.15–0.20 mm on the proximal side 0.10 mm on the distal.

Annulets in each interspace regularly spaced, in the juvenile part 5–7 per interspace, in the distal part 5–9. Annulets in the juvenile part, occasionally occurring fairly high on the distal slopes of the rings, but never distally. Annulets generally with a prosocyrt profile and sharp crests. Primary interspaces flat or slightly convex, sloping strongly inwards at 7–12°, towards long axis, the angle increasing towards the aperture, causing a serrate appearance when viewed in profile.

Very distinct lirae along the entire conch, regularly spaced with a density on the juvenile part of 5–6 per 0.1 mm. Lirae crossing the annulets, occasionally also the crests of the juvenile rings, but never the crests of the distal rings.

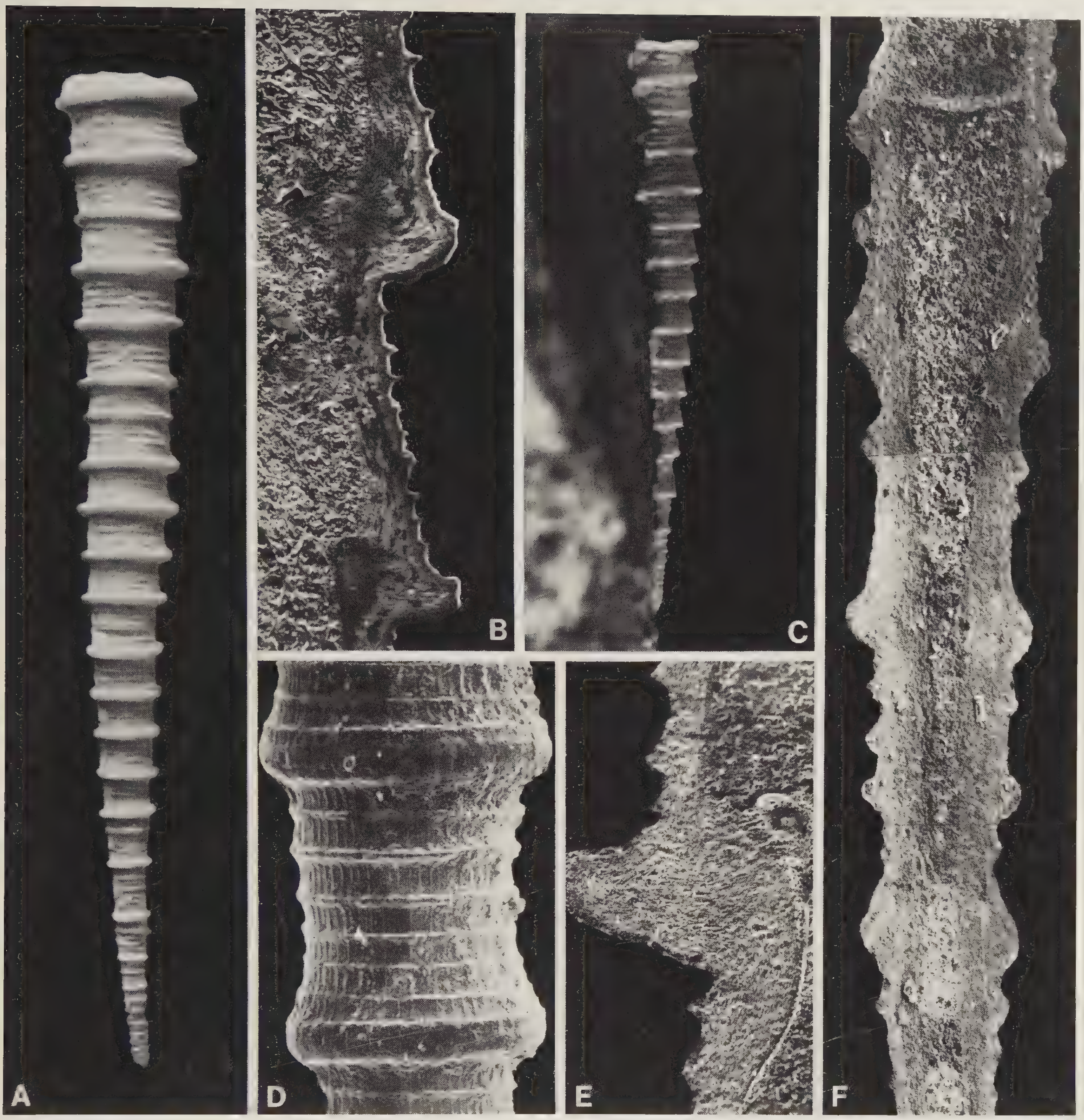


Fig. 34. Tractabilopsis serratus n. sp. A, B, C. Sudersandsviken 1, G 73-1 KL. ☐ A. Holotype, SMNH X 1112, × 15. ☐ B. Longitudinal section of distal conch wall, SMNH X 1124, × 100. ☐ C. Specimen showing serrate profile of rings, SMNH X 1113, × 12.5. ☐ D. Lateral view of juvenile primary rings and annulets, SMNH X 1125, × 75; Alnäsavik 1, G 73-10 KL. ☐ E. Longitudinal section of distal primary ring, SMNH X 1686, × 150; sample as for A–C. ☐ F. Longitudinal section of septal region, SMNH X 1122, × 75; Haganäs 1, MS 489.

Proximal septal region; septa free, the most distal septum forming at an outer conch diameter of 0.40–0.50 mm; total unknown but minimum six. Free parts of early septa perpendicular to long axis, distally formed septa commonly slightly oblique. Last four or five septa distally more concave, also considerably thicker than the early septa with thicknesses of 0.05 to 0.06 mm. Mural and free parts of these septa maintain the same thickness resulting in constriction of the interior in this part of the conch. Accretion zone with a length of 0.85–1.0 mm. Camerae occasionally almost completely filled. Mural parts of the later septa may extend 1.0–1.2 mm, approximately up to where the adult type of rings occur.

Living chamber long and distinctly conical, expanding at an angle of 3–4°. Proximal end rounded or blunt occasionally asymmetrical depending on development of the last septum. Internal wall surface of the living chamber strongly irregular, reflecting closely the inwards slope of the interspaces externally. Annular concavities of conch wall not exactly in phase with rings but displaced because of extensive accumulation of lamellae on the annular shelves. Proximal limbs thickened immensely restricting diameter of living chamber opposite the crests of the rings.

Pseudopuncta not observed. Thickness of primary shell 0.02–0.03 mm proximally to increasing gradually 0.05–0.07 mm distally.

Remarks. – The various characters of *Tractabilopsis serratus* are remarkably constant. In the juvenile part some variation may be seen in the development of the ring pattern. Either one or two smaller rings or only a few annulets may lie between the widely spaced larger rings. *Tractabilopsis serratus* is easy to recognize, even in small fragments, because of the characteristic inwards sloping attitude of the interspaces distally and the proximal ring pattern.

The distal ring pattern may show some similarity to that of *Tentaculites gothemensis* which occasionally exhibits inwards sloping interspaces. The juvenile ring patterns are completely different, however.

Occurrence. – *Tractabilopsis serratus* is restricted both geographically and stratigraphically. It has so far been found at only three localities on Fårö Island, in the Slite Marl immediately below the Ryssnäs Limestone.

Family Volynitidae Ljashenko 1969

Type genus. – *Volynites* Ljashenko 1957

Genera. – *Alekseites* Ljashenko 1969; *Arctites* Ljashenko 1969; *Bicingulites* Ljashenko 1969; *Lonchidium* d'Eichwald 1860; *Odessites* Ljashenko 1969; *Parvulites* Ljashenko 1969; *Podolites* Ljashenko 1969; *Sokolites* Ljashenko 1969; *Turmalites* Ljashenko 1969; *Volynites* Ljashenko 1957.

Stratigraphical and geographical distribution. – The members of the family occur in beds from middle Silurian to lower Devonian age in Europe, Siberia, North Africa, North America.

Remarks. – The diagnosis of the family (Ljashenko 1969a: 94) is very general and the diagnostic characters could also apply to any other family. Only five genera of the family occur in Sweden and type material has not been examined so it does not merit giving an emended diagnosis for the family.

Ljashenko (1969a: 94), in her comparison against other families, pointed out some characters which distinguish this family. It differs from Tentaculitidae Walcott in having secondary rings between the primary rings. It is distinguished from Rossiitidae Ljashenko by having annulets between the rings, and by the irregular inner wall surface of the living chamber as opposed to an entirely smooth one in adult specimens of Rossiitidae.

From the present study it is evident that the development of the initial chamber in Volynitidae differs from other families. The initial chamber has distinct bilateral symmetry and is distinguished clearly from the juvenile part by a faint constriction.

Lonchidium d'Eichwald is referred to this family because the proximal ring of each ring pair is a typical secondary ring. Besides, the distinct rhythmicity of the rings is a very significant character in Volynitidae. If *Bicingulites* Ljashenko were regarded an independent genus and not a junior synonym of *Lonchidium* d'Eichwald, it should probably be referred to this family.

As mentioned previously *Turmalites* Ljashenko is referred to this family instead of to Tentaculitidae Walcott because it has well developed secondary rings. The same feature is seen in *Parvulites* Ljashenko and *Sokolites* Ljashenko which, accordingly, are moved to Volynitidae Ljashenko.

Genus *Lonchidium* d'Eichwald 1860

Type species (selected herein). – *Lonchidium inaequale,* figured in d'Eichwald (1860, Pl. 40: 20a–b); from the Ohesaare Beds of Estonia.

Species on Gotland and in Scania. – *Lonchidium extensum* n. sp., *L. groenwalli* n. sp., *L. groetlingboense* n. sp., *L. incilense* n. sp., *L. mobergi* n. sp., *L. ogmotum* n. sp., *L. scanicum* n. sp., *L. umidestre* n. sp.

Diagnosis (new). – Small- to medium-sized genus of Volynitidae with a straight conch or slightly curved proximally. Annulation with rings and annulets perpendicular or slightly oblique to long axis. Rings rhythmically arranged, mostly in groups of two or three, occasionally four, rings. Proximal part occasionally exhibits rings without cyclic arrangement, gradually increasing in size and spacing in a distal direction. Lirae. Proximal part divided internally by free, occasionally endoconic septa. Living chamber conical with slightly irregular inner wall surface. Pseudopuncta.

Stratigraphical and geographical distribution. – The type species, *Lonchidium inaequale* d'Eichwald occurs in the Ohesaare Beds of Estonia. It has been encountered from the upper Lower and Upper Podlasian in northern Poland. On Gotland and in Scania, the genus is represented in Ludlovian and Downtonian Beds.

Remarks. – The history of this genus has already been described in the historical account. Many tentaculitids were ascribed to *Lonchidium inaequale* d'Eichwald (then as *Tentaculites inaequalis*) but most identifications should be seriously questioned. Ljashenko (1969a: 92–93) created a new genus *Bicingulites* for a tentaculitid with a bi-annulate ring pattern which 'closely resembles *Lonchidium* d'Eichwald. Most likely *Bicingulites* Ljashenko is a junior synonym but to assess this definitely the type material must be checked.

Bi-annulate ring patterns occur in other tentaculitid genera, e.g. in *Turmalites* Ljashenko and occasionally in *Podolites* Ljashenko. The double rings are never developed as distinctly as in *Lonchidium,* where each ring pair comprises one secondary ring followed by a primary ring. *Turmalites* shows pairs of primary rings. Several species of *Lonchidium* have very characteristic primary rings which have long bases and flattened crests.

Lonchidium extensum n. sp.

Figs. 18E, 35.

Derivation of name. – Latin *extensus*, stretched out, referring to the extended interspaces between the primary rings.

Holotype. – SMNH No. X 1550, Fig. 35A.

Type strata. – Hamra Beds, unit *b* (sample G 72–67 KL).

Type locality. – Bankvät 1, Gotland.

Material. – From the type locality more than 150 specimens, from additional localities about 40 specimens.

Diagnosis. – Slender *Lonchidium*, proximal part expanding at 6.5–8°, distally subcylindrical. Conch medium-sized. Annulation perpendicular to long axis, with groups of 3–7 rings proximally, 2 or 3 rings distally. Primary interspaces extended. Secondary interspaces concave, with or without annulets. Primary rings bi-convex, smooth proximal slopes, distal slopes with 2 or 3 annulets. Bases of rings wide. Crestal furrow distinct. Secondary rings with sharp crests and gentle proximal slopes. Juvenile part with free, regularly spaced septa with concave free parts. Accretion zone developed. Internal conch wall almost smooth. Diffuse pseudopuncta.

Description. – Conch slender, proximal part expanding at 6.5–8°, distally subcylindrical. Conch straight, but the very proximal end occasionally showing a slight curvature. Estimated length of conch in fully adult specimens 10–11 mm. Initial chamber unknown. Minimum outer proximal diameter 0.10 mm, outer distal diameter in adult specimens 0.80–0.85 mm. Aperture perpendicular to long axis.

Conch ornamented with rings and annulets perpendicular to long axis. Juvenile part up to the first primary ring having low rings gradually increasing distally in size and spacing. Immediately before the first primary ring, these rings commonly alternate with annulets placed centrally in each interspace. Density of rings ca. 10 per mm. Remainder of conch showing widely spaced primary rings occurring at gradually larger intervals, spacing of first two primary rings varying between 1.0 and 1.6 mm, while spacing in distal counch is ca. 1.4 and 1.6 mm. Occasionally spacing of almost 2.5 mm has been seen. First primary ring appears at an outer conch diameter of ca. 0.35–0.45 mm. In the primary interspaces 3–7 secondary rings occur proximally while two, occasionally three, rings occur distally. These rings increase gradually in size and spacing in the early primary interspaces. Secondary interspaces concave, smooth or with one annulet. Occasionally the size of the secondary rings approaches that of the annulet, and sectioning is required to differentiate between the two types of rings.

Primary rings slightly asymmetrical showing slightly opisthocline, straight axial traces, shape bi-convex with rounded crests and poorly defined hinge lines. Proximal slopes smooth, distal slopes having 2 or 3 annulets. Crestal furrow very distinct. Height: basal width of these rings distally about 1: 2–3.

Secondary rings have a similar attitude and shape to the primary rings, but longer proximal slopes. Generally the hinge line is better defined and forms the crestal line of the rings.

Annulets often occurring only sporadically between secondary rings but are always present on the distal slopes of the primary rings and the wide secondary interspaces next to them. Annulets low, margins prosocline.

Conch covered by lirae which occur in the tertiary and secondary interspaces and on the distal slopes of the rings, crossing early secondary rings and all annulets. Density of lirae varying between 7 and 10 per 0.1 mm.

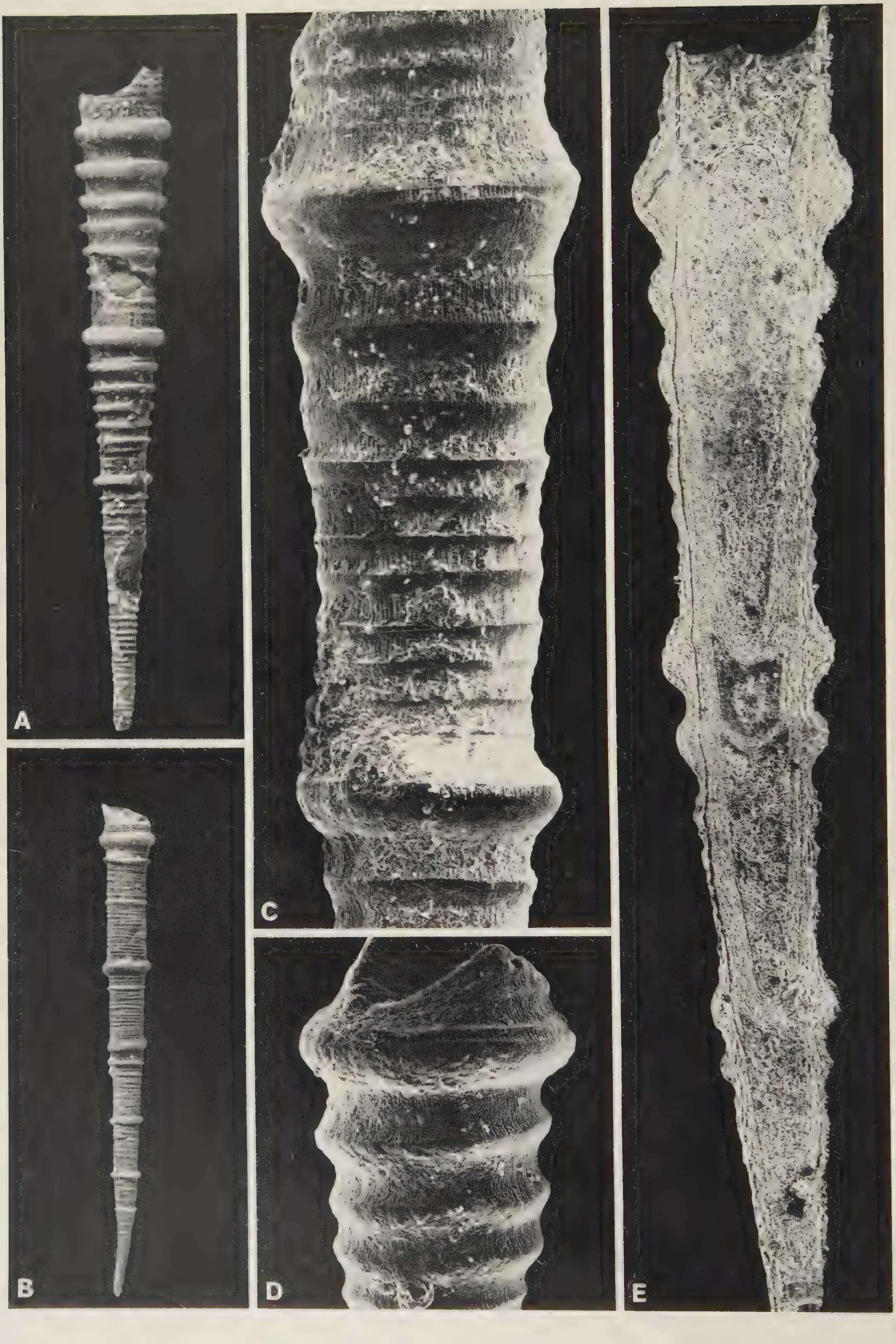
Primary interspaces flat, secondary and tertiary interspaces distinctly concave.

Proximal septal region: septa free, regularly spaced, ca. 0.23–0.28 mm apart, last septum occurring at an outer conch diameter of ca. 0.40. Accretion zone formed in the distal part of the septal region. Septa rather symmetrical and their free parts are strongly concave. Thickness of septa varies considerably within an individual.

Living chamber symmetrical, conical in its proximal part but subcylindrical more distally. Internal wall surface rather smooth only having some shallow annular

Table 13. Lonchidium extensum n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	WLCY	PA
SMNH X 1550 (holotype)	5.35	0.63	0.16	0.40		1.12	1.58	6.5°
SMNH X 1551	4.63	0.59	0.23	0.44		1.12	1.03	7°
SMNH X 1556	3.09	0.49	0.20	0.32	0.40		1.11	7°
SMNH X 1557	3.86	0.63	0.27	0.36	0.30		1.33	7°
SMNH X 1611	4.71	0.67	0.32	0.43		1.28	1.46	6.5°
SGU Te 44	9.60	0.80	0.10	0.48		1.06	2.46	8°
SGU Te 46	7.80	0.83	0.12	0.51		1.62	1.54	
SGU Te 48	8.31	0.83	0.16	0.43		1.31	1.39	


A
B
C
D
E

concavities at the rings. Primary rings have very narrow annular shelves and the annular concavities are distal to the crests of the rings.

Conch wall showing very faint pseudopuncta in the proximal limbs of the primary rings. Wall thickness 0.02–0.03 mm proximally and slightly more, 0.04–0.05 mm, distally.

Remarks. – *Lonchidium extensum* is recognized by the rather long primary interspaces, the early occurrence of the first primary ring and the furrowed distal slopes of the distal primary rings. Another characteristic is many secondary rings in the early primary interspaces. *L. extensum* is similar to and occurs with *L. groetlingboense* but in the latter species the first primary ring appears later and the primary rings have a different shape and very long proximal slopes. The spacing of the primary rings is less in *L. groetlingboense.* The furrowed distal slopes of the primary rings of some specimens of *L. extensum* are very similar to those in *Lonchidium ogmotum.* However, the latter species has much shorter primary interspaces.

The ring pattern of *Lonchidium extensum* is not consistent because the proximal secondary rings tend to vary in size. Their size may approach that of the annulets. The distal secondary ring of each cycle is always well developed and the bi-annulate ring pattern is clear.

Occurrence. – *Lonchidium extensum* is common in the fauna at Bankvät 1, Hamra Beds, unit *b.* It has not been recorded outside Gotland.

Lonchidium groenwalli n. sp.

Fig. 36.

Derivation of name. – Latin *groenwalli,* in honour of Dr. Karl A. Grönwall (1869–1944), who carried out the fundamental work on the Öved-Ramsåsa Beds in Scania.

Holotype. – SMNH No. X 1632, Fig. 36A.

Type strata. – Öved-Ramsåsa Beds, unit *3* (*sensu* Grönwall 1897). Sample Ra 71–3 KL.

Type locality. – Ramsåsa 2, Scania.

Material. – From the type locality 3 specimens, from additional localities 20 specimens.

Diagnosis. – Narrow, slender *Lonchidium,* proximal part expanding at 7–8.5°, distally subcylindrical. Proximal part with low, symmetrical rings increasing gradually in size and spacing, distal part with symmetrical or slightly asymmetrical rings in distinct cycles, proximally of 4 or 5 rings, distally 2. Primary rings bi-convex, slopes much extended, bases wide. Conch wall slightly irregular, annular concavities shallow. Poorly developed pseudopuncta.

Description. – Conch straight and slender, proximal part expanding at 7–8.5°, distally subcylindrical. Estimated total length of fully adult specimens 11–12 mm. No initial chamber found. Minimum outer proximal diameter 0.16 mm, outer distal diameter in adult specimens 0.95–1.00 mm. Aperture perpendicular to long axis of conch.

Conch ornamented with rings and annulets perpendicular to long axis, arranged rhythmically except in the most proximal part of conch where rings are regular, only increasing gradually in size and spacing towards the first primary rings. Density of juvenile rings 10–12 per mm immediately proximal of this ring. Rings symmetrical and low, separated by concave, smooth interspaces. Major part of conch having rhythmical rings. First primary ring at an outer conch diameter of 0.44–0.56 mm. Spacing of the first two primary rings varying between 1.15 and 1.65 mm, while more distal primary rings are spaced 1.00–1.40 mm apart. First two, occasionally three, cycles having 3 or 4 secondary rings, the rest of the cycles only one ring which, together with the adjacent primary ring, forms a distinct bi-annulate ring pattern distally. These two rings are close together and the interspace in the proximal part of each cycle is generally long.

Primary rings externally symmetrical or slightly asymmetrical with an opisthocline attitude. Outermost laminae hemispherical, but their curvature increases inwards where a strongly opisthocline and somewhat prosocyrt axial trace may be observed. Profile of rings bi-convex, crests gently rounded or somewhat flattened, no hinge line. Distal slopes mostly ornamented with one or two annulets: most proximal annulets on these slopes occurring rather close to crest and a faint crestal furrow is common. Proximal slopes smooth, much extended, ring bases wide, height: basal width up to 1: 5. Height of the most distal primary rings 0.14–0.16 mm.

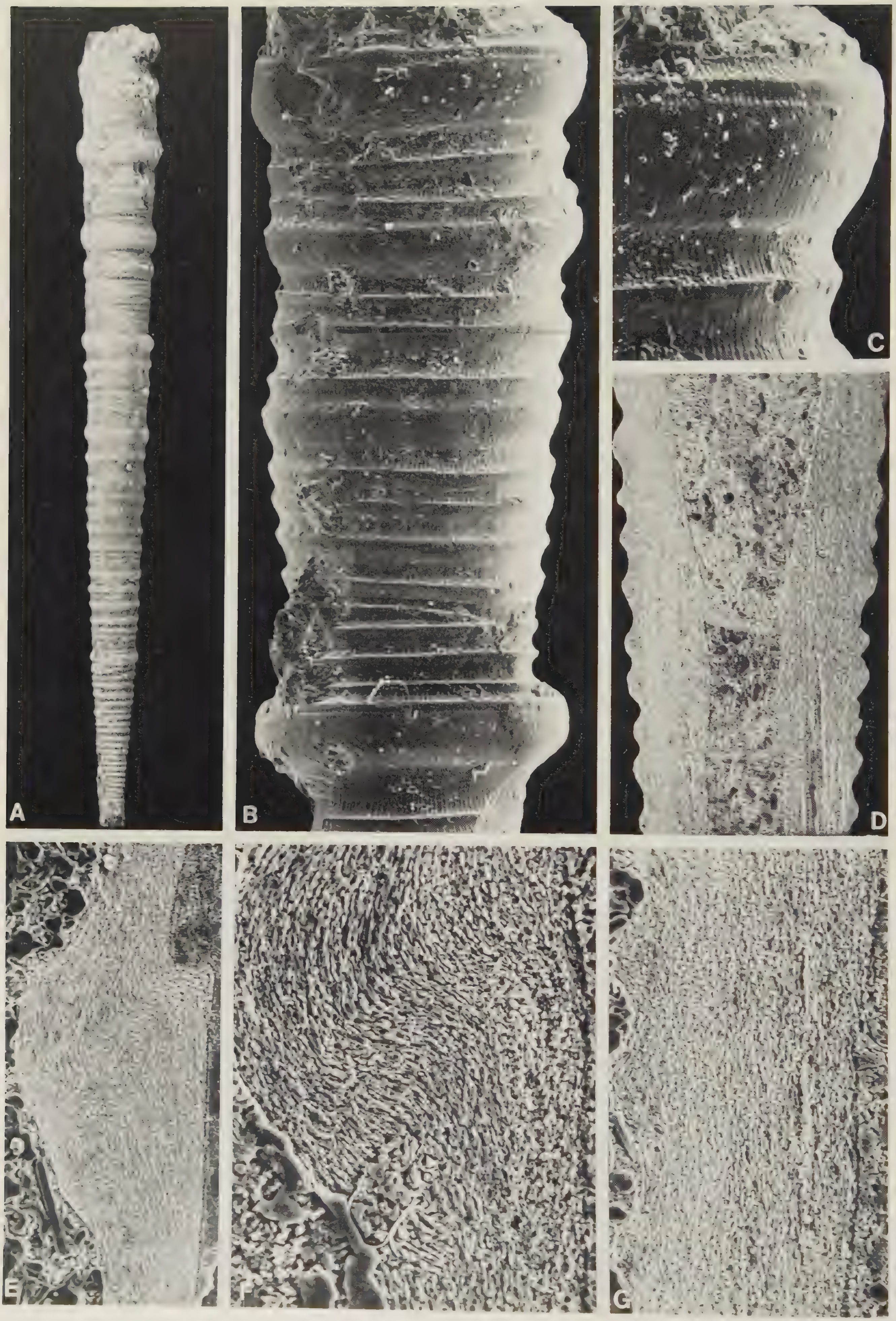
Secondary rings having a similar attitude and shape to primary rings, but are less massive and both limbs are about the same thickness. Rings generally very low. Commonly, 3–8 annulets occur in the secondary interspaces, a few on the distal slopes of the primary rings. Annulets asymmetrical with a prosocline attitude, wide bases and rather rounded crests.

Whole conch covered by lirae, occurring in interspaces, crossing crests of annulets and occurring on distal slopes of rings. However, crests of these rings generally smooth. Density of lirae 10–12 per 0.1 mm.

Secondary and tertiary interspaces slightly concave, primary interspaces always flat.

Proximal septal region: septa free, spaced rather regularly, mostly 0.25–0.30 mm apart. The 7–9 most distal septa generally form an accretion zone of 2.0–2.3 mm. These septa have asymmetrical mural parts, commonly thickened towards one side of the conch. Free parts frequently oblique to long axis. The most proximal septa

Fig. 35. Lonchidium extensum n. sp. A. Bankvät 1, G 72-67 KL. B. Bankvät 1, unnumbered SGU sample. C, D, E. Bankvät 1, MS 877. ☐ A. Holotype, SMNH X 1550, × 25. ☐ B. Specimen with atypical ring pattern, SGU type collection, × 10. ☐ C. Lateral view of primary rings and primary interspace, SMNH X 1558, × 75. ☐ D. Lateral view of first primary ring and proximal secondary rings, SMNH X 1553, × 75. ☐ E. Longitudinal section of septal region, SMNH X 1556, × 75.


A
B
C
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E
F
G

Table 14. Lonchidium groenwalli n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	WLCY	PA
SMNH X 1632 (holotype)	9.76	0.96	0.28	0.56		1.64	1.20	8°
SMNH X 1625	7.16	0.80	0.20	0.44	0.44	1.24	1.00	8°
SMNH X 1626	6.28	0.74	0.16	0.56	0.28	1.28	1.20	7.5°
SMNH X 1628	8.40	0.92	0.16	0.56	0.48	1.16	1.36	8.5°
SMNH X 1629	8.40	0.88	0.16	0.44	0.46	1.48	1.36	7°
SMNH X 1633	9.72	1.00	0.20	0.44	0.64	1.25	1.12	8°

are more symmetrical and the free and mural parts have the same thickness. Free parts of septa slightly concave. Last septum occurring at an outer conch diameter of 0.44–0.50 mm in adult specimens, exceptionally up to 0.65 mm. This septum is always conical, but with a well defined free part.

Living chamber conical proximally but gradually becoming subcylindrical distally. Wall surface of chamber rather smooth having some irregularities only at the levels of the rings. Annular concavities shallow and asymmetrical, occurring far proximal to crests of rings. Annular shelves narrow with an orthocline attitude, their shape frequently being modified by accretion of secondary shell material just proximal of shelves and on their innermost part. Secondary rings having very weak annular concavities parallelling the exterior shape of the rings.

Conch wall showing well defined primary and secondary shells. Outermost third of the very massive proximal limbs of the primary rings showing poorly developed pseudopuncta. Thickness of primary shell 0.02 mm proximally and 0.03–0.05 mm distally.

Remarks. – *Lonchidium groenwalli* is characterized particularly by the proximal ring pattern of low rings of equal size and spacing. The distal bi-annulate pattern, the low primary rings and their long bases are all significant features, used to distinguish this species from *L. mobergi* and *Odessites lebiensis* (Zagora). The latter species commonly has few secondary rings in the early primary interspaces. These rings increase gradually in size and spacing and the ring pattern becomes similar to that of *Lonchidium groenwalli.*

The intraspecific variation in *L. groenwalli* is shown in the position of the first primary ring, the number of ring cycles with more than one secondary ring and the size of the rings. There may occasionally be some variation in shape and size of the primary rings, commonly even within a specimen. Internally, the length of the accretion zone and the arrangement of the free parts of the septa may show some variation.

Fig. 36. Lonchidium groenwalli n. sp. □ A. Holotype, SMNH X 1632, × 15; Ramsåsa 2, Ra 71-3 KL. □ B, C. Lateral view of distal primary interspace and primary rings, × 75, and detail of primary ring, × 140, SGU type collection; Bjärsjölagårdborrningen 2, 5.63 m. □ D, E, F, G. Longitudinal sections of septal region, × 90, distal primary ring, × 200, detail of another distal primary ring, × 600, and detail of juvenile conch wall, × 300, SMNH X 1628; Vrangelsborg 1, Vr 66-4 LJ.

Occurrence. – *Lonchidium groenwalli* occurs from the base of unit *3* (*sensu* Grönwall 1897) up into unit *4* of the Öved-Ramsåsa Beds in Scania.

Lonchidium groetlingboense n. sp.

Fig. 37.

Derivation of name. – Latin *Groetlingboensis,* from Grötlingbo, referring to the area where the species is most abundant, and which includes the type locality.

Holotype. – SGU type collection, Fig. 37A.

Type strata. – Hamra Beds, unit *b.*

Type locality. – Bankvät 1, Gotland.

Material. – From the type locality 30 specimens, from additional localities in the Hamra Beds 27 specimens.

Diagnosis. – Slender *Lonchidium,* proximal part expanding at 5–6.5°, distally subcylindrical, medium-sized. Annulation in two patterns, proximal and early adult parts with low rings gradually increasing in size and spacing, distal part with rings in distinct groups. Rings before the first primary ring coarse and separated by concave, smooth interspaces. Adult part with widely spaced primary rings separated proximally by 2 or 3 secondary rings, distally by one secondary ring. Rings with conspicuous, long, convex proximal slopes and rounded crests. Inner conch wall moderately irregular. Poorly developed pseudopuncta.

Description. – Conch conical and slender, proximal part expanding at 5–6.5°, distal part subcylindrical. Proximal part curved slightly along ca. 0.80 mm, rest of conch straight. Length in fully adult specimens 12–13 mm. Initial chamber conical passing into juvenile part without any constriction or other delimitation. Outer conch diameter immediately behind initial chamber ca. 0.07–0.08 mm, outer distal diameter in fully adult specimens 0.90–0.95 mm. Aperture perpendicular to long axis.

Whole conch ornamented with rings and annulets perpendicular to long axis. Two principal ring patterns may be distinguished. Juvenile and early adult part up to the first primary ring having low rings with rounded crests. Rings increasing gradually distally in size and

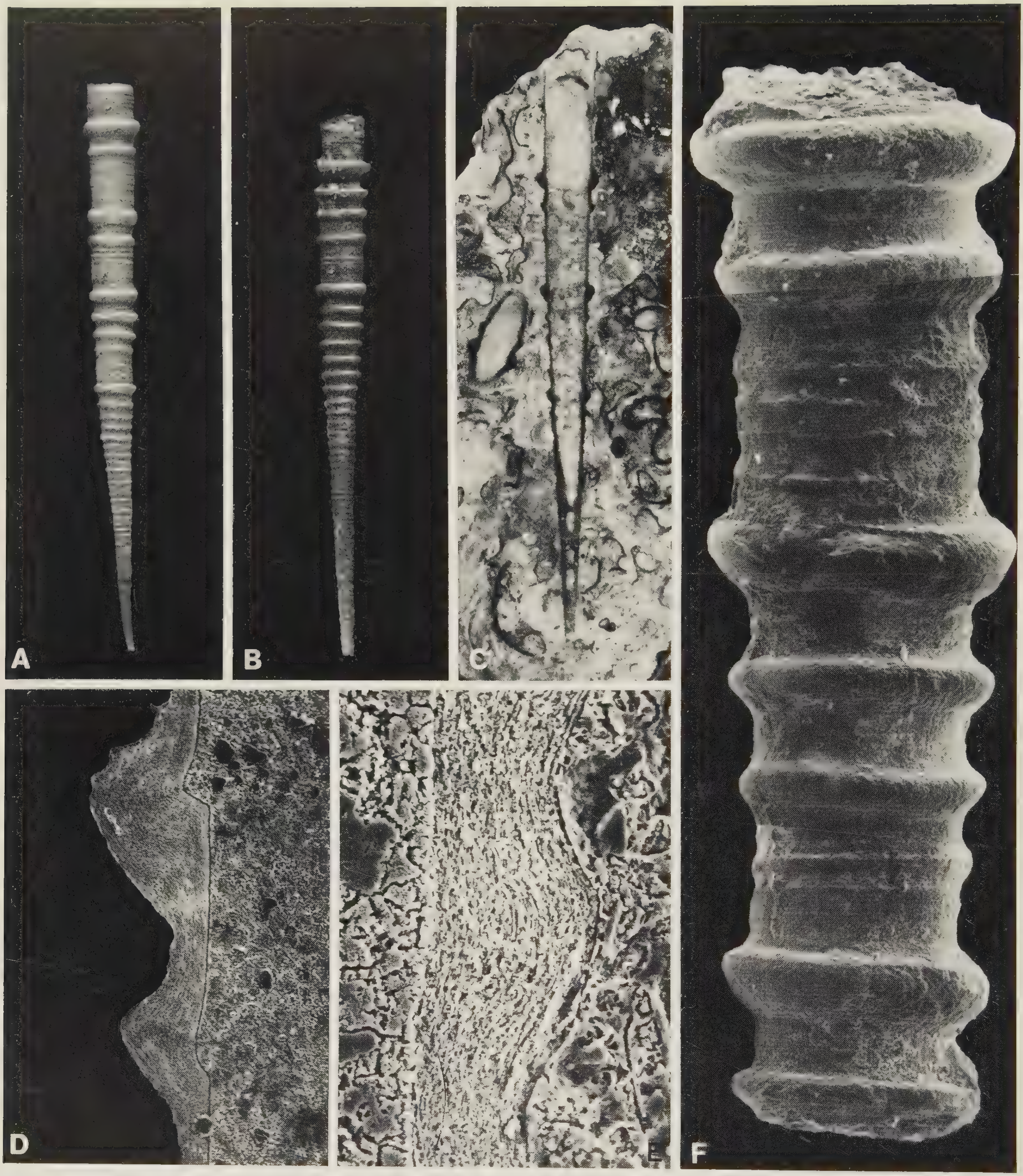

Fig. 37. Lonchidium groetlingboense n. sp. D, E, F "Grötlingboudd", unnumbered SMNH sample. ☐ A. Holotype, SGU type collection, × 10. ☐ B. SGU type collection, × 10. ☐ A, B – Bankvät 1, unnumbered SGU sample. ☐ C. Longitudinal section of almost complete specimen, SMNH X 1641, × 10. ☐ D, E. Longitudinal sections of distal ring pair, × 100, and juvenile conch wall, × 400, SMNH X 1643. ☐ F. Lateral view of early distal part, SMNH X 1642, × 50.

spacing, the increase being particularly distinct at an outer conch diameter of 0.40–0.50 mm where rings are separated by smooth, concave interspaces. Density of rings ca. 4 per mm distally, 13–15 per mm more proximally.

Major part of conch having rings in a rhythmical pattern: primary rings well spaced, separated by 2 or 3, occasionally 4, secondary rings immediately proximal to primary rings. Secondary rings increasing gradually distally in size and spacing. Distal ring pattern generally bi-annulate. Width of first cycle normally 1.30–1.50 mm. The first primary ring develops at an outer conch diameter of 0.55–0.70 mm, 5–6 mm from the proximal end. Distal primary rings showing a similar spacing, but may be at intervals of 1.90–2.10 mm.

Primary rings clearly asymmetrical having long proxi-

Table 15. Lonchidium groetlingboense n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	WLCY	PA
Holotype	9.58	0.79	0.10	0.55		1.58	1.54	6.5°
SGU Te 42	7.72	0.83	0.20	0.55		1.94	1.58	6.5°
SGU Te 43	8.20	0.83	0.10	0.53		1.70	1.47	6.5°
SGU Te 50	10.89	0.95	0.20	0.71		1.31	1.74	6.5°
SGU Te 60	8.28	0.72	0.20	0.68	0.36	1.50		6.0°
SMNH X 1397	10.20	0.81	0.14	0.63		1.48	1.38	5.5°
SMNH X 1560	8.32	0.71	0.14	0.55	0.40		1.66	5.0°
SMNH X 1641	9.66	0.91	0.16		0.40		2.33	6.0°

mal slopes, while distal slopes are shorter and steeper. Laminae forming these rings often hemispherical, axial traces consequently very diffuse or lacking, at least in the outer part of the rings. However, some rings have opisthocyrt axial traces. Primary rings bi-convex with rounded crests and smooth proximal slopes, distal slopes generally having one annulet. Height of distal primary rings 0.12–0.14 mm, height: basal width 1: 2.5.

Secondary rings asymmetrical and bi-convex in profile. These rings commonly have slightly prosocline, prosocyrt axial traces.

Annulets mainly lying in the secondary interspaces of the distal conch, rare in the juvenile part. One or, occasionally, two annulets forming on the distal slopes of the primary rings. Annulets low with prosocline crests.

Whole conch with faint lirae in secondary and tertiary interspaces, their density 8–10 per 0.1 mm.

Primary interspaces flat, secondary interspaces flat or concave, the latter shape being more common. Proximal septal region with rather regularly spaced free septa. Last septum in adult specimens generally forming at an outer conch diameter of 0.40 mm. Septa mainly symmetrical but, occasionally, slightly asymmetrical septa occur as well. Free parts strongly concave, sometimes slightly irregular in course, mural parts tapering rapidly. Last 4 or 5 septa commonly forming an accretion zone which may be up to 2.5–2.8 mm long.

Living chamber conical proximally, but gradually becomes subcylindrical distally. Internal wall surface slightly irregular because of incomplete filling of annular concavities. These lie at the ring crest or slightly distal to it. Annular shelves narrow, having a prosocline attitude. Annular concavities of secondary rings always proximal to crest of rings.

Faint pseudopuncta occasionally occurring in the proximal limbs of the primary rings. Thickness of primary shell 0.02–0.03 mm proximally and 0.04–0.05 mm distally.

Remarks. – *Lonchidium groetlingboense* is characterized by the long proximal part which has progressively larger and more widely spaced rings, the late appearance of the first primary ring, and the very conspicuous rings with long proximal slopes. The proximal annulation distinguishes this species from other *Lonchidium* species, i.e. *L. extensum* and *L. umidestre*. *Lonchidium groetlingboense* resembles *L. groenwalli* the younger representative of the genus in Scania, but differs from it mainly in having a longer proximal part and generally larger conch.

The ring pattern of *Lonchidium groetlingboense* varies to some extent. The rings immediately before the first primary rings are occasionally more closely spaced and not much different in size from earlier rings in the juvenile part. The number of secondary rings in the distal cycles and the spacing between primary rings may vary.

Occurrence. – *Lonchidium groetlingboense* has only been identified definitely from the Hamra Beds, units *b* and *c*, mainly in the Bankvät–Grötlingboudd area. It is occasionally very numerous.

Lonchidium incilense n. sp.

Fig. 38.

Derivation of name. – Latin *incilensis*, from the ditch, referring to the type locality for the species.

Holotype. – SMNH No. X 1490, Fig. 38A.

Type strata. – Öved-Ramsåsa Beds unit *1a* (sample Bj 74–2 KL).

Type locality. – Bjärsjölagård 1, Scania.

Material. – From the type locality 5 specimens, from additional localities 22 specimens.

Diagnosis. – Small to medium-sized *Lonchidium* with a proximal growth angle of 7–8.5°, distal part expanding at 4–5°. Proximal part distinctly curved. Juvenile part with narrow, secondary rings sharply crested in profile, gradually increasing in size and spacing. Distal annulation of rings perpendicular to the long axis, in cycles of two closely spaced but differently sized rings separated by wide, flat interspaces with numerous annulets. Living chamber conical with slightly irregular internal wall surface. Pseudopuncta.

Description. – Proximal part of conch expanding at 7–8.5°, distal part at 4–5°, change in growth angle gradual. Distal straight but proximally distinctly curved. Deflection of

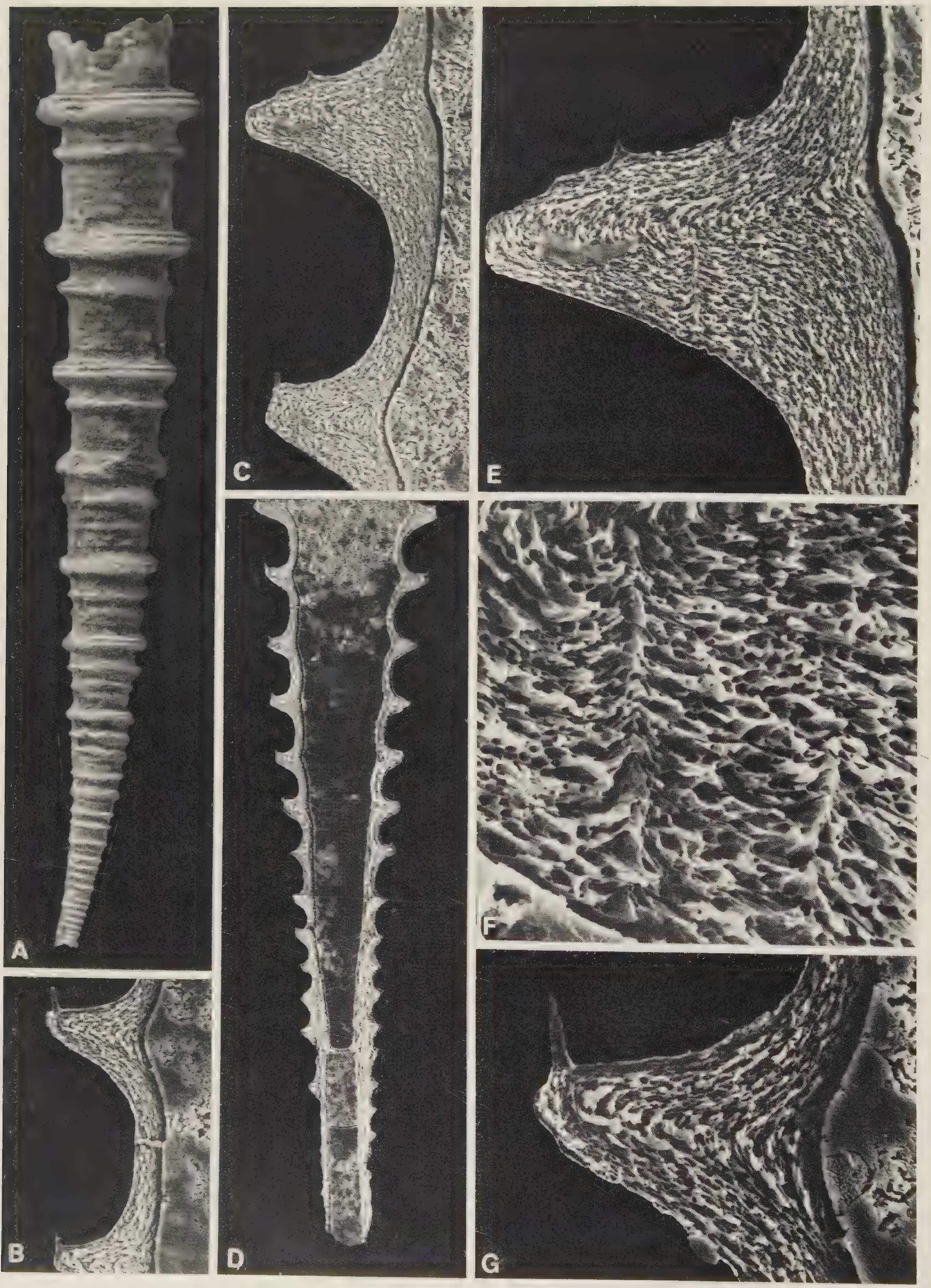
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Table 16. Lonchidium incilense n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WLCY	PA
SMNH X 1490 (holotype)	6.85	0.87	0.16	0.24		1.03	8.5°
SMNH X 1480	5.42	0.75	0.20	0.24		0.95	8°
SMNH X 1494	8.39	0.59	0.12	0.24	0.43	1.82	8°
SMNH X 1495	4.87	0.59	0.10	0.32	0.22	0.97	7°
SGU Te 1	4.16	0.59	0.24			0.79	8°
SGU Te 2	4.47	0.51	0.16	0.28		0.61	7.5°

apical point from a sagittal plane through the living chamber 0.20–0.25 mm. Length of conch in fully mature specimens estimated as 9–11 mm. Initial chamber unknown. Minimum outer proximal diameter ca. 0.10 mm, outer distal diameter in mature specimens 0.85–0.90 mm. Aperture perpendicular to long axis of conch.

External surface of conch having rhythmic annulation with rings perpendicular to long axis of conch. Proximal part with distinct rings increasing gradually in size and spacing towards the distal end, density ca. 14–16 rings per mm. Rhythmicity of ring pattern less distinct in proximal part and does not become well developed until an outer conch diameter of ca. 0.25–0.30 mm, where the first true primary ring occurs. Secondary rings proximal to this ring slightly asymmetrical with orthocline or slightly prosocline and straight axial traces, shape slightly convexo-concave or angular with rather pointed crests. Each secondary ring has a strongly prosocline and straight flange fringing the hinge line (Fig. 38G). This flange is almost perpendicular to the distal slope of the ring. Slopes of rings smooth. Interspaces distinctly concave and symmetrical. No annulets occur in the interspaces.

Distal conch having distinctly rhythmic rings. The earliest three or four cycles each have three or occasionally four rings. However, most of the distal part has only two rings in each cycle. In the distal conch, more than half the width of each cycle consists of a long proximal interspace. Distal ring pairs consisting of a secondary ring followed immediately by a distinct primary ring. Primary rings spaced 0.40–0.55 mm apart proximally, but ca. 1.0–1.10 mm distally. Spacing between secondary and primary ring of each pair ca. 0.20–0.30 mm in the early adult part and 0.30–0.40 mm more distally. Primary rings increasing distinctly in size towards the distal end, symmetrical or slightly asymmetrical with straight or faintly opisthocline and straight axial traces. Proximal slopes smooth, distal slopes having 1–3 coarse annulets making the ring appear strongly furrowed. The most distal primary ring occasionally reaching heights of ca. 0.16 mm. Height: basal width about 1: 1.

Distal secondary rings having a similar attitude to those proximally, but differ in having less steep slopes and only one coarse annulet on the distal slope. Distal conch having distinct annulets in the interspaces. The wide secondary interspace before each secondary ring has 7 or 8 annulets, the short interspaces between secondary and primary rings only 1 or 2. The wide interspaces are flat, while the short interspaces are concave.

Lirae present but very weakly developed. In the material available it was not possible to measure their density.

Proximal septal region with septa. The most distal septum observed was at an outer conch diameter of ca 0.43 mm. However, this septum probably does not represent the last septum of a fully adult individual because the sectioned specimen is rather small. Free parts straight or slightly concave and perpendicular to long axis, spacing 0.2–0.3 mm. Mural parts of septa symmetrical and comparatively short, initially having the same thickness as the free parts but taper rapidly. Because no fully mature specimens have been found, the development of the most distal septa is unknown.

Living chamber conical and initially symmetrical. Character of internal wall surface in mature specimens unknown. Wall surface in young specimens irregular, roughly reflecting the external features of the conch. Annular concavities close to aperture filled rapidly. In the primary rings only very weak annular shelves distal to the crest of the rings develop. The secondary rings have more central, narrow annular shelves.

Primary shell having well developed pseudopuncta in the proximal limbs of the primary rings. Primary shell distinguished from the secondary shell by a comparatively thick inner organic layer. Thickness of primary shell 0.02–0.03 proximally and slightly more, 0.04–0.05 mm, in the early distal part.

Remarks. – The available material of *Lonchidium incilense* shows little variation. The species is very similar to *L. ogmotum* and the two species may easily be confused, especially if only adult portions are available. The most striking similarity is the coarse annulets on the distal slopes of the rings. However, the juvenile parts differ. *L. incilense* has more, sharper secondary rings, and a more curved proximal end. *Lonchidium incilense* has a somewhat wider conch and a more conical living chamber than *L. ogmotum.* The proximal part of *L. incilense* shows some resemblance to that of *L. scanicum* but differs in the general shape of the rings and the lack of oblique rings.

Fig. 38. Lonchidium incilense n. sp. ☐ A. Holotype, SMNH X 1490, ×25; Bjärsjölagård 1, Bj 74-2 KL. ☐ B, C, D. Longitudinal sections of juvenile rings, ×250, of ring pair, ×250, of septal region, ×75. ☐ E, F, G. Details of primary ring in C, ×500, of pseudopuncta in E, ×1750, and of distal ring in D, ×750. ☐ B–E. Same specimen, SGU type collection, Bjärsjölagårdborrningen 1, 67.0–67.7 m.

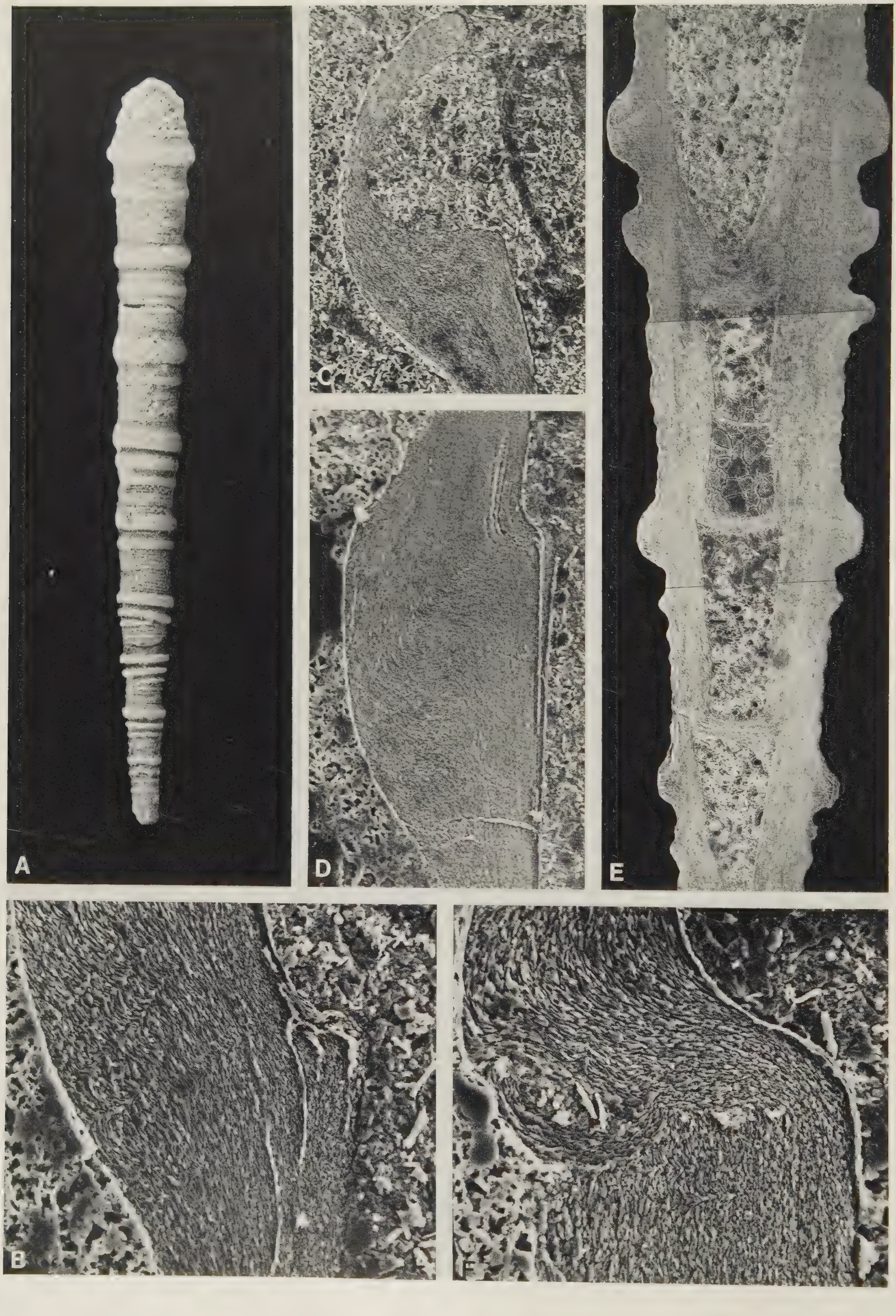
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Table 17. Lonchidium mobergi n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	WLCY	PA
SMNH X 1620 (holotype)	8.92	0.92	0.24	0.30		0.60	1.36	7°
SMNH X 1614	9.20	0.80	0.24	0.28		0.60	1.68	8°
SMNH X 1615	5.00	0.60	0.14	0.26	0.26	0.50	1.12	6.5°
SMNH X 1616	7.00	0.64	0.16	0.30	0.40	0.46	0.88	8°
SMNH X 1617	9.79	0.88	0.20	0.28		0.60	1.52	8°
SMNH X 1621	7.68	0.84	0.24	0.32	0.48	0.56	1.08	6.5°
SMNH X 1644	5.20	0.60	0.12	0.26	0.44	0.48	1.28	7°

Occurrence. – *Lonchidium incilense* is restricted to the Öved-Ramsåsa Beds, unit *1a*. It occurs in the borehole Bjärsjölagårdborrningen 1 54.10–69.00 m below the wellhead. At the type locality, Bjärsjölagård 1, it comes from beds with the *Hindeodella excavata* fauna *sensu* Jeppsson (1974).

Lonchidium mobergi n. sp.

Figs. 19B–C, 39.

Synonymy. – □ ? *Tentaculites schlotheimi* Koken – Hajłasz (1974: 470–471, Pl. 6: 3).

Derivation of name. – In honour of Johan Christian Moberg (1854–1915) who, together with K. A. Grönwall, investigated the Öved-Ramsåsa Beds in Scania.

Holotype. – SMNH No. X 1620, Fig. 39A.

Type strata. – Öved-Ramsåsa Beds, unit *3* (*sensu* Grönwall 1897). Sample Ra G 67–2 LJ.

Type locality. – Ramsåsa 9, Scania.

Material. – From the type locality 4 specimens, from additional localities 14 specimens.

Diagnosis. – Narrow, medium-sized *Lonchidium* slightly curved proximally, straight distally. Annulation with distinct rings in rhythmic pattern of pairs of triplets. Primary rings closely spaced, the first two rings 0.45–0.60 mm apart. Primary rings with very extended slopes and flat or slightly rounded crests. Living chamber with slightly irregular inner conch wall. Pseudopuncta well developed.

Description. – Conch narrow and slender, proximal part expanding at 6.5–8°, distally subcylindrical. Conch straight except for the very proximal part which may be slightly curved, occasionally deflected up to 0.30 mm from a sagittal plane through the aperture of the conch. Length of fully adult conch estimated as 10–11 mm. Initial chamber unknown. Minimum outer proximal diameter 0.12 mm, outer distal diameter in fully adult specimens is 0.95–1.00 mm. Aperture perpendicular to long axis of conch.

Fig. 39. Lonchidium mobergi n. sp. □ A. Holotype, SMNH X 1620, × 15; Ramsåsa 9, Ra G 66-2 LJ. □ B, C, D, E, F. Longitudinal sections of proximal limb of distal primary ring, × 500, of primary ring forming the aperture, × 200, of juvenile primary ring, × 200, of septal region, × 75, and detail of repaired conch wall, × 500, SMNH X 1621; Ramsåsa 2, Ra 71-3KL.

Whole conch ornamented by rings and annulets perpendicular to long axis. Rings rhythmically arranged in cycles of 2–4 rings proximally and two rings distally. First primary ring appearing at an outer conch diameter of 0.26–0.32 mm. Proximal primary rings closely spaced, the first two ca. 0.50–0.60 mm apart, distal spacing ca. 1.50–1.70 mm. Part proximal to the first primary ring having low rings gradually increasing distally in size and spacing. Their density immediately before the first primary ring 14–16 per mm.

Primary rings slightly asymmetrical with an opisthocline attitude and strongly opisthocline and straight axial traces. Outermost laminae commonly hemispherical. Profile of rings bi-convex with very extended slopes and flat or slightly rounded crest, hinge line weakly developed. Proximal slopes smooth, distal slopes having one or two annulets. Generally there is a crestal furrow between the crestal line and the first annulet on each primary ring. Height: basal width of proximal primary rings about 1: 3, distally, the ratio is 1: 4–5 and the height of the rings ca. 0.10 mm.

Secondary rings having a slightly asymmetrical attitude, but having prosocline, straight or slightly prosocyrt axial traces. Profile bi-convex, occasionally convexo-concave and with rounded crests. Size of secondary rings within each cycle increasing gradually. First rings occasionally low. Annulets occurring between rings and on distal slopes of primary rings at close regular intervals. The long secondary interspace of each cycle has no more than 12 or 13 annulets which are low, symmetrical and rather cuspate.

The material was not well enough preserved for study of the lirae. However, there is no reason to believe lirae to be missing.

Secondary and tertiary interspaces concave, primary interspaces flat.

Proximal septal region with free septa occurring at regular intervals, 0.3–0.4 mm apart. Distal 3 or 4 septa normally form an accretion zone up to 1.0–1.5 mm. Free parts concave and perpendicular or oblique to long axis of conch. The most distal septum occurs at an outer conch diameter of 0.45–0.50 mm and it is generally asymmetrical and conical. Free part of this septum very thick but mural part tapers rapidly.

Living chamber proximally conical but rapidly becomes subcylindrical towards aperture. Internal wall surface slightly irregular. Annular concavities at primary rings shallow, asymmetrical, and concavities at secondary rings more symmetrical. Former concavities far distal to crest of ring, while the latter concavities more or less parallel the external shape of the secondary rings. Annular shelves of primary rings straight or slightly prosocline, commonly modified by accretion of secondary shell material.

Primary and secondary shells easily distinguished. Outermost part of proximal limbs of primary rings having well developed pseudopuncta. The latter occur also in some secondary rings, and in the distal limbs of the rings and in the interspaces. Thickness of primary shell ca. 0.02 mm proximally and 0.03–0.05 mm distally.

Remarks. – *Lonchidium mobergi* is characterized mainly by the relatively early cyclicity of the ring pattern and dense primary rings. The ring pattern and shape of the rings in the distal part are similar to *L. groenwalli*. *Lonchidium mobergi* may be distinguished by its having shorter intervals between primary rings.

The specimen figured by Hajłasz (1974, Pl. 6: 3) and described as *Tentaculites schlotheim* Koken might be referred to *Lonchidium mobergi*. Unfortunately, Hajłasz' (1974) description is vague and the illustration poor. The figure shows the specimen to have a bi-annulate and tri-annulate ring pattern and primary rings with wide bases. The stratigraphical level at the top of the *N. incerta–A. prima* zone (*sensu* Tomczykowa & Witwicka 1974) fits with the distribution of *Lonchidium mobergi* in Scania.

In *L. mobergi* the number of rings in the first three or four cycles is variable. There may occasionally be some variation in their number more distally when tri-annulate cycles form.

Occurrence. – *Lonchidium mobergi* appears close to the base of unit *3* (*sensu* Grönwall 1897) of the Öved-Ramsåsa Beds and ranges up into the next unit, *4*.

Lonchidium ogmotum n. sp.

Fig. 40.

Derivation of name. – Greek *ogmotos* – full of furrows, referring to the conspicuous grooves on the distal slopes of the rings, produced by the coarse annulets.

Holotype. – SMNH No. X 1479, Fig. 40A.

Type strata. – Öved-Ramsåsa Beds, unit *1* (sample Kl 67–24 LJ, 4.96 m above base of section).

Type locality. – Klinta 2, Scania.

Material. – From type locality 19 specimens, from additional localities in Öved-Ramsåsa Beds 47 specimens; from Gotland 11 specimens from Eke Beds, 37 from Burgsvik Beds, 3 from Hamra Beds.

Diagnosis. – Medium-sized *Lonchidium* with coarse annulets on distal slopes of the rings giving a furrowed appearance. Growth angle 6.5–8° proximally, 2–3° distally.

Description. – Conch expanding at 6.5–8° proximally, gradually changing to 2–3° distally. Mainly straight, but occasionally with slight proximal curvature. Maximum length estimated at 10–12 mm, no initial chamber found. Minimum outer proximal diameter 0.10 mm, maximum outer distal diameter 0.95–1.00 mm; aperture always perpendicular to long axis.

Rings and annulets prominent over the whole conch, rings always perpendicular to long axis. Rings generally paired, occasionally in groups of three in the first two or three cycles. Primary rings gradually larger and more widely spaced towards distal end. Width of cycles 0.55–0.65 m proximally, 0.95–1.25 mm distally. Spacing of primary from secondary rings of cycle also increasing distally. Distance between crests of rings of pairs 0.20 mm proximally, 0.30–0.40 mm distally. Pairs consisting of secondary ring followed by a primary ring of conspicuously different size. Primary rings almost symmetrical, axial trace opisthocline and slightly opisthocyrt but becoming diffuse in outermost part where laminae are hemispherical. Proximal slope of primary ring smooth and convex, distal slope with coarse annulets giving a pronounced furrowing of the surface; crest of ring gently

Table 18. Lonchidium ogmotum n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WLCY	PA
SMNH X 1479 (holotype)	9.11	0.87	0.14	0.22		1.23	6.5°
SMNH X 1484	6.57	0.59	0.16	0.18		1.15	7.5°
SMNH X 1485	7.37	0.99	0.48			1.23	
SMNH X 1486	9.27	0.95	0.16			1.23	8°
SMNH X 1487	9.30	0.99	0.20			0.93	8°
SMNH X 1488	7.25	0.71	0.24	0.32		1.09	8°
SMNH X 1492	7.05	0.67	0.10		0.36	1.25	
SMNH X 1493	7.80	0.83	0.12	0.26		0.99	8°

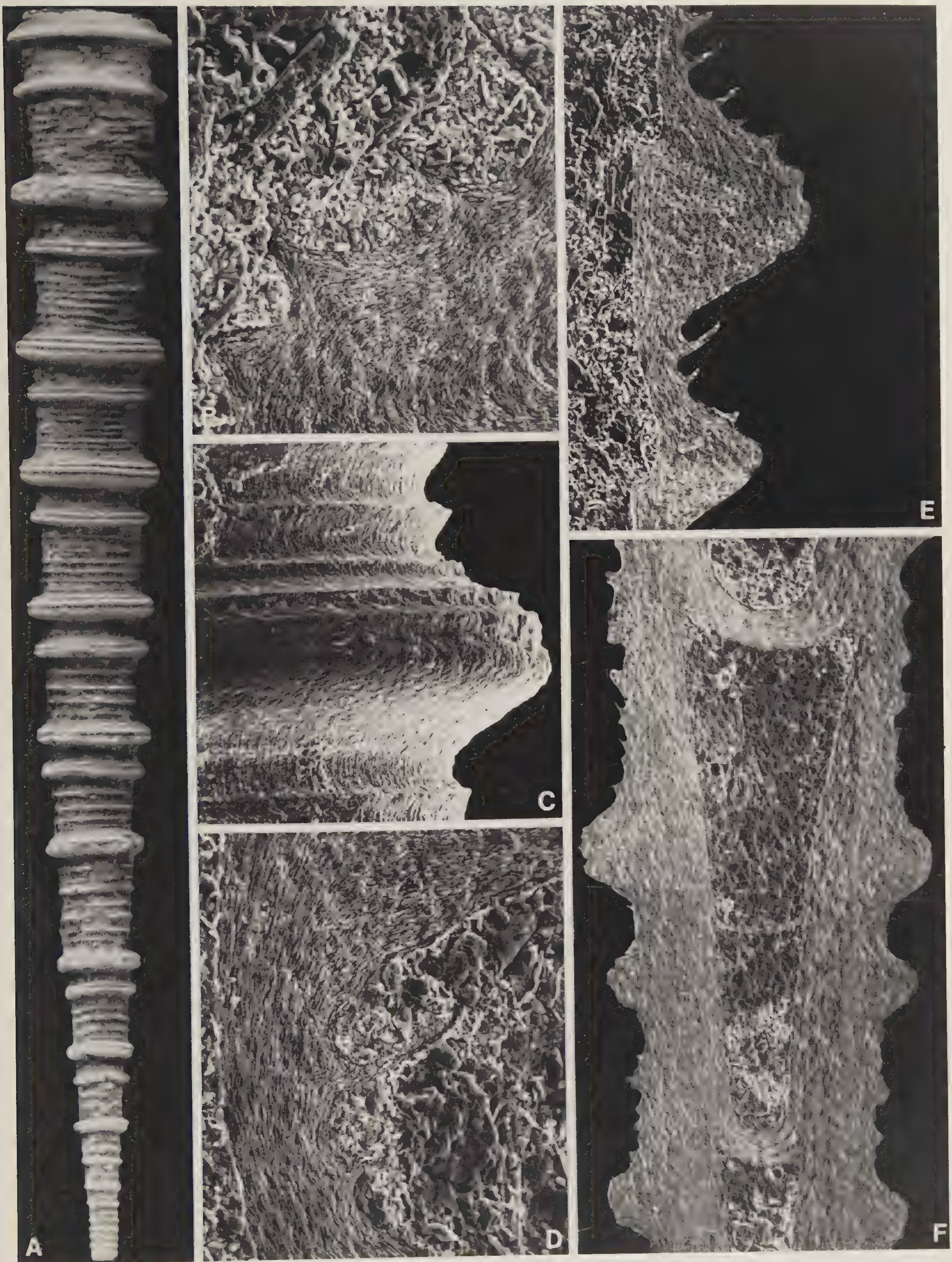


Fig. 40. Lonchidium ogmotum n. sp. □ A. Holotype, SMNH X 1479, ×25; Klinta 1, Kl 67-21 LJ. □ B, D, E, F. Longitudinal sections showing detail of distal side of primary ring, ×250, annulets and proximal limb of secondary ring, ×400, distal ring part, ×150, and septal region, ×150, SMNH X 1492;Klinta 2, Kl 67-23 LJ. □ C. Lateral view of primary ring, SGU type collection, ×150; Bjärsjölagårdborrningen 1, 27.0–27.1 m.

rounded. Distal primary ring height 0.15 mm, height: basal width of ring 1: 1.7–1.8. Secondary rings symmetrical, axial trace orthocline, profile sub-triangular with slightly convex slopes and narrow rounded crest, distal slope generally with one central annulet. Coarse, well-defined annulets in interspaces and on distal slopes of rings. Annulets symmetrical, with wide base and thin, prosocyrt, wide outer margin; regularly spaced, 10–12 per mm proximally, 18–20 per mm distally. In adult cycles, 8–10 annulets in wide proximal interspace, 2 or 3 between paired rings, 2 or 3 on distal slope of rings. Height of annulet above interspace up to 0.06–0.07 mm. Proximal interspace of each cycle wide, often more than half the cycle width, flat, sloping inwards slightly – as is best seen in sections of the internal surface. Shorter interspaces of cycle concave. Lirae in all tertiary interspaces and may extend onto proximal slopes of rings, weakly developed, 18–20 per 0.1 mm.

Proximal septal region, early septa free, later septa partly endoconic. Free septa symmetrical, regularly spaced, 0.25–0.30 mm apart; total unknown but minimum 7; thickness 0.04–0.05 mm, maintained in mural part, but very thin septa may also be present. Free parts of septa concave, especially in distal septal region. Mural parts of proximal septa parallel to long axis and forming narrow extended camerae, of distal septa diverging from long axis and forming conical camerae with narrow, concave proximal ends and wide, convex distal ends. Distal 3 or 4 septa generally distinctly endoconic. Last septum at conch diameter of 0.30–0.35 mm.

Living chamber conical, symmetrical, with narrow, pointed proximal end. Internal wall surface slightly irregular because of incomplete filling of annular concavities. Primary rings largely filled, even near aperture, proximal limbs with greatest lamellar accumulation; annular shelves narrow, opisthocline, distal to ring crest. Secondary rings largely filled, but more homogeneous lamellar accumulation; annular shelves narrow, proximal to ring crest. Inner and outer surfaces of interspaces parallel.

Pseudopuncta in proximal limb of rings, variously developed in the different rings, of very low tubercles. Primary and secondary shells fairly distinct, especially in juvenile part where separated by a thin inner organic layer. Thickness of primary shell fairly uniform, 0.03 mm proximally, 0.04 mm distally.

Remarks. – *Lonchidium ogmotum* is characterized chiefly by the furrowed appearance that the coarse annulets give to distal slopes of rings. Well-defined paired rings are another characteristic feature. Morphological features show negligible variation, *L. ogmotum* is closely related to *L. incilense,* and adult parts of the two species may be difficult to distinguish.

Occurrence. – *L. ogmotum* is most abundant in Scania in unit *1a* (*sensu* Grönwall 1897) of the Öved-Ramsåsa Beds. It has only been definitely identified from beds with *Hindeodella steinhornensis scanica* and *Hindeodella wimani* faunas *sensu* Jeppsson (1974). On Gotland, definite identification has been made from a few localities in basal Burgsvik Beds and uppermost Eke Beds, but the species is not common.

Lonchidium scanicum n. sp.

Figs. 7A–B, 9C, 41.

Derivation of name. – Latin *scanicus,* from Scania, referring to the location of the type locality.

Holotype. – SMNH No. X 1458, Fig. 41A.

Type strata. – Öved-Ramsåsa Beds, unit *1* (sample KL 74–7 KL, collected 2.55 m above the base of the measured section).

Type locality. – Klinta 1, Scania.

Material. – From the type locality 92 specimen, from additional localities in the Öved-Ramsåsa Beds 47 specimens;from Gotland, 11 specimens from the Eke Beds, 37 specimens from the Burgsvik Beds and 3 specimens from the Hamra Beds.

Diagnosis. – Small- to medium-sized *Lonchidium* with narrow conch proximally expanding at 4.5–6.5°, distally slightly less. Annulation slightly oblique, consisting of rings arranged into cycles with rings in pairs. Rings asymmetrical with extended proximal slopes and steep distal slopes. Septa distally forming an accretion zone.

Table 19. Lonchidium scanicum n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	PA
SMNH X 1458 (holotype)	7.72	0.71	0.12	0.46		1.07	5.5°
SMNH X 1459	9.10	0.71	0.16	0.46		0.99	5°
SMNH X 1460	7.52	0.79	0.20	0.47		1.26	5°
SMNH X 1461	5.03	0.59	0.10	0.44		1.03	5°
SMNH X 1465	9.50	0.91	0.16	0.63		1.11	5°
SMNH X 1470	6.49	0.63	0.16	0.48	0.28	1.29	5°
SMNH X 1471	9.11	0.69	0.14	0.53	0.32	0.95	4.5°
SMNH X 1473	5.36	0.67	0.18	0.36	0.28	0.89	6.5°
SMNH X 1476	8.12	0.79	0.12	0.55		1.11	5°
SMNH X 1580	6.30	0.59	0.10	0.40	0.26		4.5°

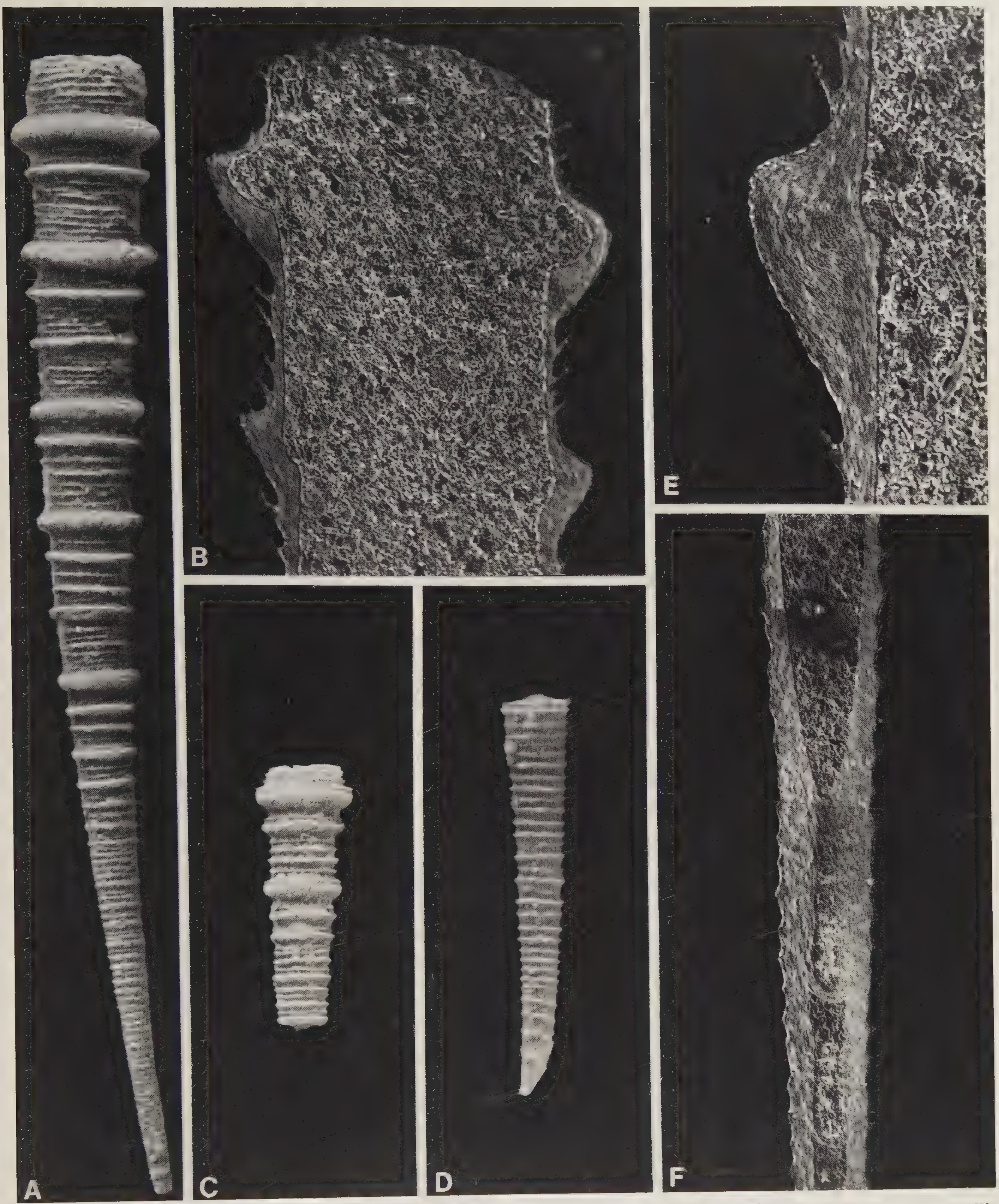


Fig. 41. Lonchidium scanicum n. sp. ☐ A. Holotype, SMNH X 1458, ×25; Klinta 1, Kl 74-7 KL. ☐B, E, F. Longitudinal sections of distal part with preserved functional aperture, ×100, distal primary ring, ×200, and septal region, ×75. Note the well developed accretion zone in F. SMNH X 1580; Klinta 1, Kl 67-10 LJ. ☐ C. Fragmented conch showing first two ring pairs, ×25, SMNH X 1478; Gisle 1, G 75-16 KL. ☐ D. Juvenile part and initial chamber, ×50, SMNH X 1481; Klinta 1, Kl 74-7 KL.

Internal wall surface smooth or almost smooth distally, only interrupted by shallow annular concavities. Conch wall without pseudopuncta.

Description. – Conch narrow, proximal part expanding at 4.5–6.5°, distal part expanding at a slightly smaller angle, change in growth angle gradual. Straight, except proximal part frequently with slight curvature up to first primary ring. Maximum deflexion of proximal end from sagittal plane through aperture 0.35–0.40 mm, average deflexion 0.15–0.25 mm. Small- to medium-sized, i.e. length 8–11 mm. Smallest outer proximal diameter 0.08–0.10 mm, although probably not the minimum diameter because no initial chamber found. Outer distal diameter 0.80–0.90 mm. Aperture perpendicular or slightly oblique to long axis.

Annulation of two ring patterns characteristic of the principal parts of conch, perpendicular or oblique to long axis, the latter orientation predominant. Proximal part with low ring of gradually greater size and spacing, rings separated by smooth, concave interspaces except the 4 or 5 rings immediately before first primary ring whose interspaces each have one annulet. Ring density 20–22 per mm at extreme proximal end but only 5–7 per mm close to first primary ring. Outer conch diameter at first primary ring generally 0.36–0.64 mm, mostly 0.45. Rings symmetrical, low, crests gently rounded.

Distal ring pattern cyclic, 2–4 rings per cycle. Second or third cycle commonly with 3 or 4 rings and longer, 1.20–1.25 mm, than adjacent cycles, most other cycles with two rings. Length of distal cycles 0.90–1.20 mm. Up to 6 or 7 cycles in fully adult conchs. Each cycle with one distal primary ring and, immediately proximal of it, one, occasionally two, secondary rings, thus forming distinct ring pairs in distal part of cycle, a marked, wide interspace up to over half the cycle width in proximal part of cycle. Distance between crests of paired rings increasing gradually, from ca. 0.2 mm most proximally to 0.30–0.40 mm most distally, distinct size difference between primary and secondary ring of pair.

Rings distinctly asymmetrical, flattened, with much extended proximal slopes and rather steep distal slopes. Axial trace of rings rather diffuse because of more or less hemispherical laminae but, when visible, opisthocline and prosocyrt. Hinge line often coincident with crestal line. Profile of rings bi-convex, crests rounded. Height: basal width of the primary rings 1: 3, bases of the secondary rings slightly narrower and ratio of 1: 2. Height of most distal primary rings seldom exceeding 0.1 mm. Proximal slopes of rings always smooth, distal slope with one or two annulets.

Well-developed annulets in all interspaces and on distal slopes of rings, on the latter earliest annulet close to hinge line. Crestal furrow commonly distinct. Annulets regular, 8–16 wide proximal interspace of each cycle, 2–4 in short interspace separating paired rings. Annulets thin, prosocline, margins prosocyrt and frequently prominent, appearing curled.

Secondary interspaces flat, well defined, always subparallel to long axis. Tertiary interspaces concave.

Lirae covering whole conch, very weakly developed so not possible to study in detail, density in one specimen of ca. 14 per 0.1 mm.

Proximal septal region; 7–10 transverse septa, well separated, at regular intervals 0.27–0.35 mm apart. Septa often asymmetrical, with oblique free parts and with mural parts of different lengths, the shorter mural part towards the concave curvature of the juvenile part. Proximal septa thin, the 4 or 5 most distal septa thickened and forming an accretion zone up to 1.0–1.5 mm long. Last septum in mature specimens at conch diameter of 0.26–0.32 mm, commonly pronouncedly conical in shape with a pointed, narrow free part.

Living chamber subcylindrical except for the proximal part which is conical, internal wall surface smooth proximally and only slightly irregular distally, the latter because of incomplete filling of annular concavities. Annular shelves generally mostly narrow and prosocline, in primary rings clearly distal to ring crests, in secondary rings clearly proximal ring crests. No pseudopuncta observed. Thickness of primary shell ca. 0.01 mm proximally, ca. 0.025 mm distally. In juvenile part, total thickness of conch wall increased considerably by thick mural parts of septa.

Remarks. – *Lonchidium scanicum* is characterized chiefly by the conspicuously asymmetrical rings and their oblique arrangement, and by the curved proximal part. However, all these features vary somewhat among specimens. The proximal slopes may be steeper. The size of the secondary rings immediately proximal of the first primary ring may also vary; in some specimens, particularly those with larger conchs, these rings are widely spaced and approach the size of the following primary ring.

L. scanicum shows similarities to several other *Lonchidium* species, e.g., *L. ogmotum, L. groenwalli,* and *L. extensum.* It differs from the first species essentially in the development of the rings; those in *L. scanicum* are lower, more asymmetrical and lack the coarse annulets on their distal slopes which characterize *L. ogmotum.* Compared with *L. groenwalli, L. scanicum* has rings of similar shape but there are less per cycle, and the first primary ring forms at a smaller conch diameter. The general ring pattern and shape of the rings in *L. scanicum* are similar to those of *L. extensum,* but the former species has shorter cycles and fewer rings per cycle.

Occurrence. – *Lonchidium scanicum* is the dominant species in uppermost unit *1a* and occurs through unit *1b* of the Öved-Ramsåsa Beds in Scania. In terms of the conodont zonation proposed by Jeppsson (1974) the range corresponds to the older and younger *Hindeodella steinhornensis scanica* faunas. On Gotland, *L. scanicum* has been found from the uppermost Eke Beds to unit *a* of the Hamra Beds.

Lonchidium umidestre n. sp.

Fig. 42.

Derivation of name. – Latin *umidum,* a wet place, referring to the type locality.

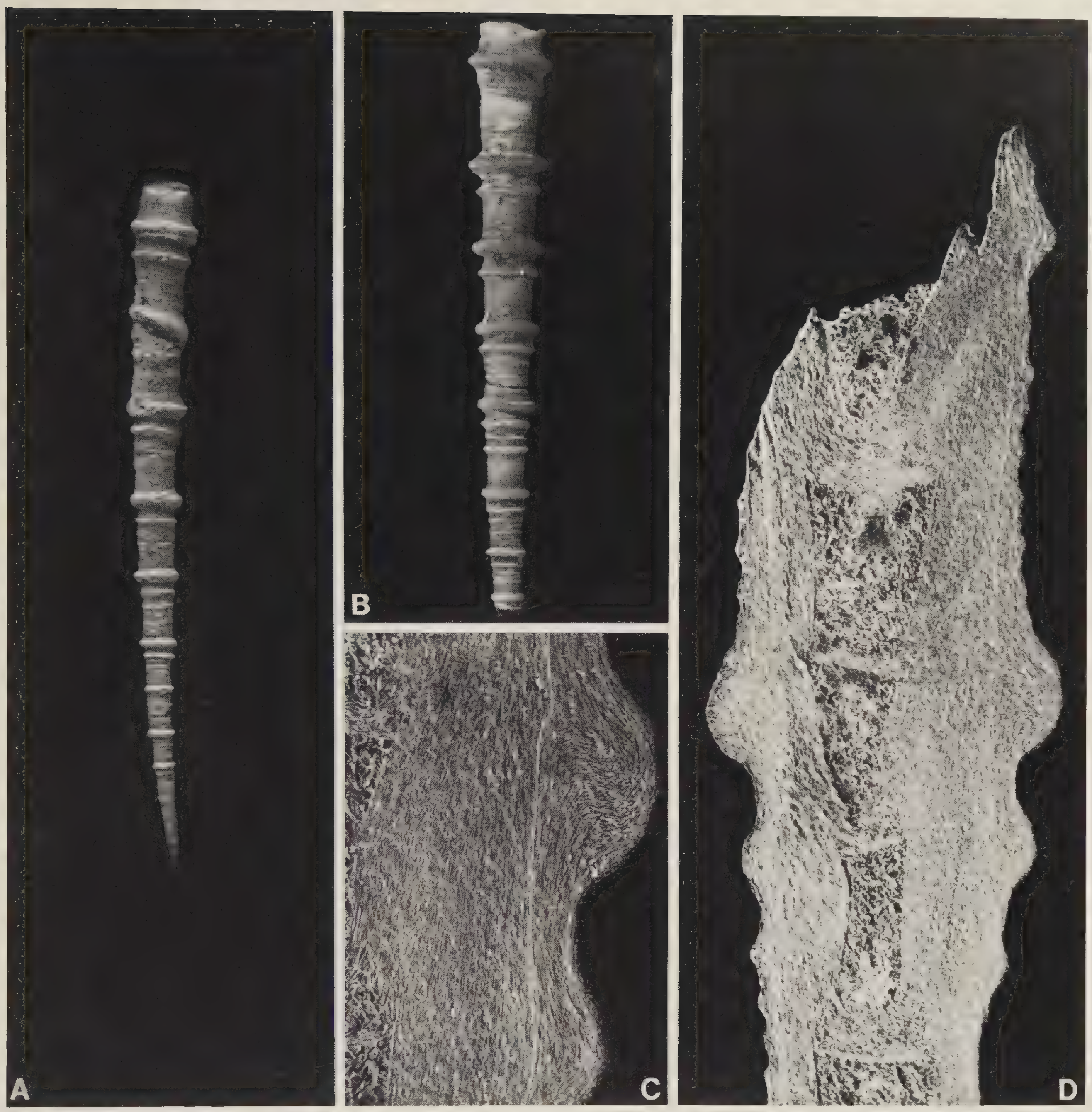


Fig. 42. Lonchidium umidestre n. sp. A. Bankvät 1, unnumbered SGU sample. B. Bankvät 1, MS 876; C, D. Bankvät 1, G 72-68 KL. ☐ A. Almost complete specimen, SGU type collection, × 10. ☐ B. Holotype, SMNH X 1561, × 10. ☐ C, D. Longitudinal sections of septa and conch wall, × 175, and septal region, × 100, SMNH X 1563.

Table 20. Lonchidium umidestre n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	WLCY	PA
SMNH X 1561 (holotype)	9.30	0.93	0.36				1.58	7°
SMNH X 1562	2.65	0.47	0.22	0.30	0.44	0.50	0.67	7.5°
SMNH X 1563	2.97	0.51	0.28		0.51		0.85	
SMNH X 1564	1.98	0.36	0.14				0.61	6°
SGU Te 54	10.69	0.83	0.08	0.30		0.51	1.58	7°
SGU Te 58	7.00	0.75	0.14	0.28		0.80	1.20	8°
SGU Te 59	11.32	0.88	0.20	0.28		0.56	2.32	8°

Holotype. – SMNH No. X 1561, Fig. 42B.

Type strata. – Hamra Beds, unit *b* (sample MS 876).

Type locality. – Bankvät 1, Gotland.

Material. – From the type locality 13 specimens, from additional localities in the Hamra Beds 10 specimens.

Diagnosis. – Slender straight *Lonchidium,* proximal part expanding at 6–8°, distal part subcylindrical. Conch medium-sized, annulation of widely spaced, paired rings, early distal part occasionally with three rings per group. Annulation perpendicular to the long axis. Rings bi-convex in profile, crests rounded with pronounced crestal furrow. One to three annulets on distal slopes of primary rings, occasionally coarse and giving a furrowed appearance to the slopes. Weak pseudopuncta in the proximal limbs of the primary rings.

Description. – Conch narrow, straight, medium-sized, proximal part expanding at 6–8°, distal part subcylindrical. Adult specimens 11–13 mm long, no initial chamber found. Minimum outer proximal diameter 0.08 mm, outer distal diameter in adult specimens 0.85–0.95 mm. Aperture perpendicular to long axis.

Ornament over whole conch, of rings and annulets perpendicular to long axis. Rings mostly paired, occasionally in threes in the very early cycles of the adult part. First primary ring at outer conch diameter of 0.28–0.33 mm. Proximal to this, rings regularly spaced, low density close to the first primary ring of 16–20 per mm. Spacing of primary rings gradually increasing, from ca. 0.5 mm to ca. 1.50–1.60 mm most distally. Spacing of secondary from primary ring of pair increasing from ca. 0.25 mm proximally to ca. 0.50 mm distally. Long secondary interspace in proximal part of each cycle with regularly spaced annulets, 4–6 proximally, 8–10 distally; secondary interspaces between paired rings with 2 or 3 annulets. Distal slopes of the primary rings with one or several annulets, the latter giving a strongly furrowed appearance.

Primary rings symmetrical or slightly asymmetrical, opisthocline; if asymmetrical, with slightly opisthocyrt axial traces. Outermost laminae commonly hemispherical. Rings with bi-convex profile, smooth proximal slopes, distal slopes either with one annulet close to crest and thus producing a distinct crestal furrow or with several annulets giving the slopes a furrowed appearance, the latter arrangement particularly common in the most distal primary rings. Height of distal primary rings 0.15–0.17 mm, height: basal width 1: 1.8–2.0. Secondary rings symmetrical, with straight and orthocline, axial traces, bi-convex, crests gently rounded.

Annulets low, slightly asymmetrical, prosocline, margins sharp.

Lirae covering whole conch, in secondary and tertiary interspaces, density 8–10 per 0.1 mm.

Proximal septal region with free, regularly spaced septa. Septa 0.30–0.40 mm apart, generally more widely spaced proximally than distally. Proximal septa with thin free parts perpendicular to the long axis and straight or slightly concave, mural parts rather symmetrical. Distal 4 or 5 septa in adult specimens frequently more asymmetrical and forming accretion zone with narrow, irregularly shaped camerae, free parts either perpendicular or oblique and either straight or slightly concave, mural parts strongly asymmetrical and irregular in thickness. Most distal septum commonly very conical and up to 0.10–0.15 mm thick, formed at outer conch diameter of 0.40–0.50 mm.

Living chamber poorly known because few specimens available for sectioning. Proximal part conical and, judging from external shape of distal conch, distal part subcylindrical.

Conch wall with primary and secondary shells well separated by thick inner organic layer. Weak pseudopuncta in proximal limbs of primary rings. Thickness of primary shell proximally ca. 0.02 mm.

Remarks. – The material available is too scanty for study of intraspecific variation. The ring pattern very much resembles that of *Lonchidium ogmotum,* and there are other similarities in the development of the distal slopes of the primary rings. *Lonchidium umidestre* is distinguished from *L. ogmotum* by having longer intervals between primary rings and flatter crests to rings. *L. umidestre* is similar to *Lonchidium extensum* but has longer intervals between primary rings and more secondary rings in the proximal cycles.

Occurrence. – *Lonchidium umidestre* has only been found and is rare at a few localities in unit *b* of the Hamra Beds.

Genus *Odessites* Ljashenko 1969

Type species (by original designation). – *Odessites spasovi* Ljashenko 1969; from the Lower Devonian of southwestern Russia.

Specis on Gotland and in Scania. – *Odessites geretiensis* n. sp., *O. inflatus* n. sp., *O. lauensis* n. sp., *O. lebiensis* (Zagora), *O. majstriensis* n. sp., *O. petilus* n. sp., *O. portensis* n. sp., *O. prolatus* n. sp.

Diagnosis (emended). – Volynitidae with large- to medium-sized, straight conchs. Initial chamber bilaterally symmetrical, clearly distinguished from the juvenile part by a slight constriction. Annulation perpendicular to long axis, of widely spaced primary rings alternating with numerous secondary rings equal in size and spacing. Annulets abundant, in the interspaces and on the distal slopes of the rings. Lirae well developed. Proximal part divided internally by free septa, commonly distally forming an accretion zone. Internal wall of living chamber irregular. Pseudopuncta present or absent.

Stratigraphical and geographical distribution. – The type species occurs in the Lower Devonian of southwest Russia (Podolia and Odessa district). Another Russian species occurs in the Lower Devonian of Siberia. In the Baltic area, *Odessites* species have been found in the Ludlovian–Downtonian Beds of Sweden and Podlasian Beds of northern Poland.

Remarks. – The diagnosis agrees largely with the original diagnosis by Ljashenko (1969a: 96) but is emended to include the shape of the initial chamber, the commonly found development of an accretion zone and possession in several species of pseudopuncta. The genus is rather similar to *Podolites* Ljashenko bud differs by having a more uniform size and spacing of the secondary rings and a larger number of these rings in each cycle.

Odessites geretiensis n. sp.

Fig. 43.

Synonymy. – ☐ *Tentaculites* cf. *ornatus* Sowerby–Hede, 1919b: 130.

Derivation of name. – Latin *geretiensis,* from Gerete, referring to the type locality where this species is dominant.

Holotype. – SMNH No. X 1326, Fig. 43A.

Type strata. – Hemse Beds, northwestern part (sample G 73–54 KL).

Type locality. – Gerete 1, Gotland.

Material. – From the type locality 110 specimens, from additional localities in the Hemse Beds 52 specimens. From Skarhult 1, Scania, about 20 specimens have been found.

Diagnosis. – Slender *Odessites* with a proximal growth angle of 5–7°. Annulation with rings, distally showing weak tendency to form cycles of 3 or 4 rings, proximally regular, widely spaced and alternating with numerous annulets. Interior with few, free septa proximally, free parts straight or concave, perpendicular or oblique. Conch wall without pseudopuncta.

Description. – Conch slender, proximal part expanding at 5–7°, distal part at 3–4°. Change of growth angle gradual. Conch straight along its full length, medium sized with an average length in fully adult specimens of 12–14 mm. Initial chamber unknown. Minimum outer proximal diameter 0.10 mm, outer distal diameter 0.90–1.00 mm. Aperture perpendicular to long axis.

Whole conch ornamented by a slightly cyclic ring pattern with rings and annulets. Cyclic groups of 3 or 4 rings often very indistinct, when the annulation consists of rings increasing gradually in size and spacing towards the distal end. Proximal rings occur regularly and groups of rings do not become distinct until a conch diameter of ca. 0.40 is reached. Distal cycles composed of 3 or 4 rings spaced 0.55–1.58 mm apart. Width of cycles increasing in a distal direction. Most distal cycle often distinctly longer, with a length of 2.0–2.5 mm. Size of rings increasing towards the distal end, but this gradation may be rather diffuse. Primary rings differentiated clearly, particularly in interior of conch. Rings asymmetrical with slightly prosocline and prosocyrt axial traces, occasionally almost orthocline, gently convexo-concave or bi-convex in profile, with rounded crests and rather distinct hinge lines, commonly coinciding with the crestal line. Some rings in juvenile part occasionally with rather sharp crests. Proximal slopes always smooth while distal slopes show lirae and one or more annulets. Maximum height of distal rings ca. 0.10 mm, height: basal width about 1: 1.

Annulets occupy interspaces and distal slopes of rings, in proximal part 5–10 in each interspace, but the number decreasing to 3 or 4 per interspace distally. Proximal rings generally with only one annulet far down on the distal slope. As new rings form, the position of this annulet changes gradually to successively higher and new annulets are added. Annulets mostly well spaced. Spacing in proximal part 0.15–0.20 mm, slightly less distally, 0.06–0.10 mm. Annulets clearly asymmetrical with a prosocline and slightly prosocyrt attitude.

Distinct lirae along entire conch, crossing crests of annulets, occurring on the distal slopes of rings almost up to the hinge line. Density of lirae 8–9 per 0.1 mm in the proximal part and 5–6 per 0.1 mm distally.

Primary interspaces flat or somewhat concave, distally commonly sloping distinctly inwards at 1–2° to the long axis, more proximally sloping inwards or being parallel to long axis. Tertiary interspaces always clearly concave.

Proximal septal region: septa well spaced, comparatively few and occupying the very proximal part. In specimens sectioned, the last septum is developed at an outer conch diameter of 0.24–0.30 mm. However, these specimens probably do not represent fully adult individuals. Septa generally rather thin and uniform except for the last one, which is thicker. Last septum occasionally asymmetrical while proximal septa are mainly symmetrical. Free parts of septa straight or concave, and mostly perpendicular to long axis although slightly oblique septa have been observed in a few specimens. Mural parts of the septa persistent.

Living chamber symmetrical, long and conical. Proximal end generally blunt. Internal wall surface irregular, especially in distal part because of incompletely filled annular concavities. Concavities generally parallel with external shape of rings. Annular shelves rounded and prosocline. Because the interspaces slope inwards, the living chamber is slightly wider immediately after than before the rings.

No pseudopuncta observed. Primary shell easily distinguished from secondary shell proximally, but generally more difficult to differentiate distally. Thickness of primary shell rather uniform, 0.03–0.04 mm.

Remarks. – *Odessites geretiensis* is characterized by the slender shape of the conch and the arrangement of the rings, distally into a weakly cyclic pattern and proximally widely spaced and separated by interspaces with numerous annulets. The proximal ring pattern is rather similar to that in *Odessites inflatus,* but the spacing of the rings is generally wider in *Odessites geretiensis.* The distal ring

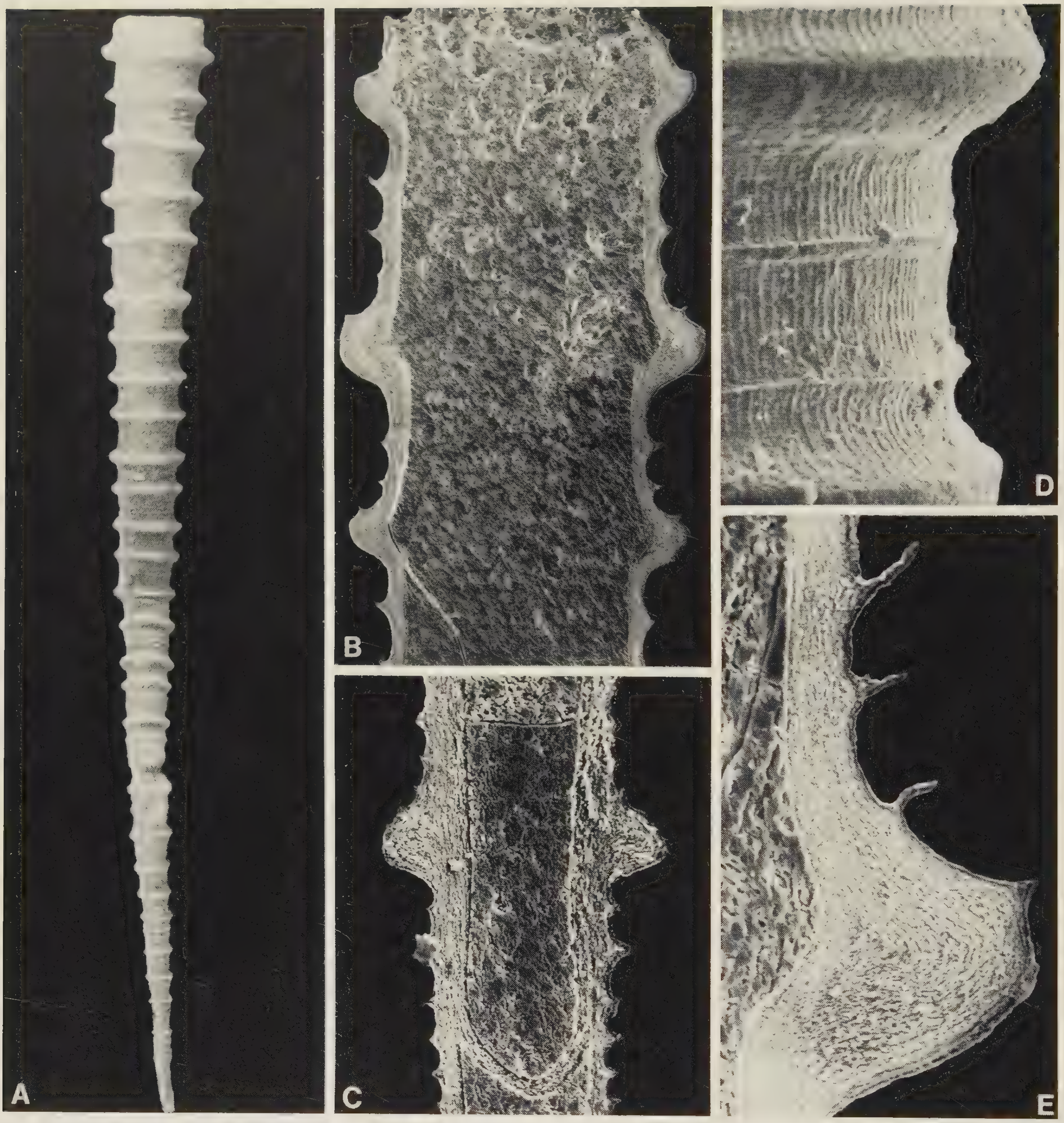


Fig. 43. Odessites geretiensis n. sp. B, D, E – Sigvalde 1, MS 274. C. Skarhult 1, Sk AM-2. ☐ A. Holotype, SMNH X 1326, ×15; Gerete 1, G 73-54 KL. ☐ B, E. Longitudinal sections of distal part, ×65, and of primary ring and annulets, ×300, SMNH X 1337; ☐ C. Longitudinal section of septal region, SMNH X 1341, ×150. ☐ D. Lateral view of primary interspace, SMNH X 1336, ×125.

pattern in *Odessites geretiensis* with its slightly inward sloping interspaces resembles to some extent that in *Tentaculites gothemensis.* However, the latter species generally has more strongly inward sloping interspaces and the shape of the rings is different.

Hede (1919b: 130) briefly described a specimen from Skarhult as *Tentaculites* cf. *ornatus* Sowerby. It is clear that the species designated this name agrees in all details with *Odessites geretiensis.*

Occurrence. – *Odessites geretiensis* dominates samples from

Table 21. Odessites geretiensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1326 (holotype)	11.26	0.99	0.10		5.5°
SMNH X 1327	7.44	0.87	0.20		6.5°
SMNH X 1328	9.94	0.71	0.16		5.5°
SMNH X 1329	8.91	0.71	0.20		5°
SMNH X 1330	11.68	0.75	0.20		5°
SMNH X 1338	6.22	0.51	0.16	0.24	
SMNH X 1344	8.71	0.75	0.26	0.30	7°

the Gerete area in the northwestern part of the Hemse Beds. It is distributed also to the northeast, in the Östergarn area. A questionable occurrence at Kullands 1 suggests that it extends from the base of the Hemse Beds in their central area. That it ranges up to the upper part of the Hemse Beds is suggested by occurrence at Sandarve 1, Livide 1 and possibly Rangsarve 1. However, the number of adequately preserved specimens from these three localities is too low to confirm this youngest occurrence. It has not been encountered in samples from the southeasern part of the Hemse Beds. In Scania, it has only been found at Skarhult in the middle part of the *Colonus* Shale.

Odessites inflatus n. sp.

Fig. 44.

Derivation of name. – Latin *inflatus,* swollen, referring to the distal primary rings.

Holotype. – SMNH No. X 1361, Fig. 44A.

Type strata. – Hemse Beds, uppermost part (sample G 73–49 KL).

Type locality. – Gogs 1, Gotland.

Material. – From the type locality 35 specimens, from additional localities in the Hemse Beds about 400 specimens.

Diagnosis. – Medium sized, narrow *Odessites,* proximal part expanding at 4–6°, distal part at 2–3°. Primary rings distinct except in the early adult part, increasing gradually in size and spacing towards the distal end. Distal primary rings large and very prominent, bi-convex with rounded crests. Secondary rings within each cycle mostly of one size, regularly spaced. Proximal part divided into camerae by numerous septa. Internal wall surface with very prominent annular shelves in the rings. Few pseudopuncta.

Description. – Conch slender, expanding at a proximal growth angle of 4–6°, the rate of expansion in many specimens being maintained the same along the entire conch, but slight decrease to 2–3° also being common. The change occurs at an outer conch diameter of ca. 0.45–0.50 mm. Conch straight except for the very proximal part, showing slight curvature, medium sized with an estimated full length in adult specimens of 12–15 mm.

Initial chamber bilaterally symmetrical with a slightly oval outline if viewed perpendicular to the sagittal plane, triangular if viewed along this plane. Two distinct, oblique rings occur on the chamber. Chamber clearly distinguished from juvenile part by a slight decrease in outer conch diameter, commonly to 0.07–0.08 mm. Length of initial chamber ca. 0.15 mm.

Aperture perpendicular to long axis. Outer distal conch diameter in mature specimens 0.90–1.10 mm.

Whole conch ornamented with rings of various orders in a distinctly cyclic pattern. All rings behind initial chamber perpendicular to long axis of conch. Annulation include distinct primary rings and secondary rings of essentially one size. Primary rings regularly spaced, increasing gradually in size and spacing towards the distal end. Early adult part often showing a less clearly rhythmical development of rings and with rings of one size and regularly spaced. First primary ring developed early in the juvenile part at an outer conch diameter of 0.15 mm, i.e. ca. 0.40 mm behind the initial chamber. Primary rings particularly prominent in distal conch, proximal spacing 0.25–0.40 mm, distal spacing generally 1.40–2.50 mm. In particularly large specimens, the two most distal rings may be 2.80–3.00 mm apart. Numerous secondary rings occurring between primary rings. Each primary interspace with 3–5 secondary rings in early juvenile part. More distally this number increases to 5–7 rings while the most distal primary interspaces generally have 4 or 5 regularly spaced secondary rings which maintain one size across the interspace. In the juvenile part a gradual slight increase in size is common. Interspace somewhat wider between the primary ring and the first secondary ring of the next cycle than the additional secondary interspaces of the cycle. Difference in width is small, however, and in many cycles no difference is noticed. Some specimens which have widely spaced primary rings at the distal end, shows an irregular spacing of the secondary rings.

Juvenile and early adult rings slightly asymmetrical, axial trace faintly prosocline and prosocyrt close to hinge line, inwards rapidly becoming orthocline and straight. Profile of rings convex-concave. Hinge lines generally distal to the crestal lines, in early rings sharp in section but gradually becoming more rounded. Height of primary rings in juvenile part up to the level of last septum 0.02–0.05 mm. Secondary rings reach about half that height. Height: basal width for both rings 1: 1. Primary rings of adult part of conch very prominent symmetrical and showing hemisphaerical outermost laminae. This lamination disappears inwards and an opisthocline, straight axial trace may be distinguished. Profile of primary rings bi-convex, crests gently rounded. Proximal slopes smooth while distal slopes show annulets and lirae. Height of distal primary rings 0.25–0.30 mm and height: basal width 1: 0.7–0.8.

Secondary interspaces and distal slopes of rings with annulets in proximal part of conch, occasionally difficult to distinguish from the comparatively small secondary rings. There is commonly a gradual transition in each cycle between the two types of rings. No annulets occurring on the slopes of the rings in the proximal part. In early distal part none, one, or occasionally two annulets in each secondary interspace may occur. When only one annulet occurs, it is commonly close to the crestal line of the ring. Number of annulets increasing towards the distal end where there may be 5 or 6 in each interspace and the same number on the distal slopes of the primary rings. Spacing of annulets regular. Annulets generally prosocline but opisthocyrt in section. Curvature more pronounced close to the distal end. Height of distal annulets 0.03–0.04 mm.

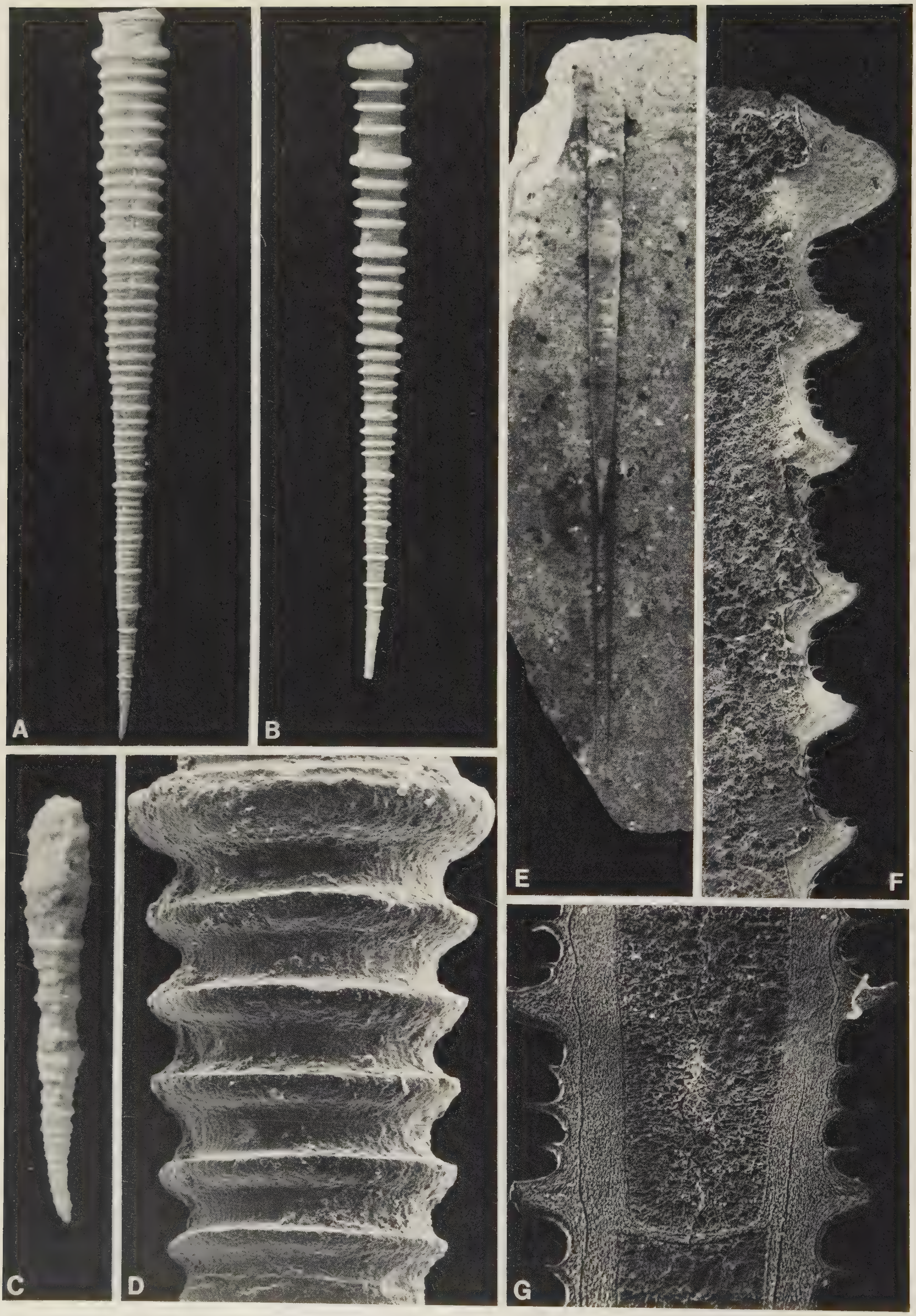

A
B
C
D
E
F
G

Table 22. Odessites inflatus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	TNCY	WLCY	PA
SMNH X 1361 (holotype)	13.70	1.07	0.12		13	2.14	4°
SMNH X 1345	8.79	0.67	0.20		7	1.70	4°
SMNH X 1350	9.70	0.79	0.14		11	1.56	5°
SMNH X 1351	12.28	0.75	0.12		10	1.82	5°
SMNH X 1352	8.51	0.71	0.26	0.32	8	1.92	5.5°
SMNH X 1353	9.54	0.67	0.14	0.36	7	1.90	6°
SMNH X 1359	6.53	0.61	0.28	0.34	6	1.46	
SMNH X 1360	8.47	0.69	0.26	0.41	4	2.22	
SMNH X 1363	9.90	0.79	0.18		13	1.23	4°
SMNH X 1368	5.15	0.55	0.24	0.30			4.5°

Secondary and tertiary interspaces clearly concave, the former sloping inwards by up to 10–12° to long axis towards distal end.

Tertiary interspaces with comparatively weak lirae, occasionally as faint traces immediately proximal to hinge lines of rings. Lirae very low and occurring at 6–7 per 0.1 mm.

Proximal septal region with numerous, frequently 12–20, septa. Last septum generally formed at an outer conch diameter in mature specimens of 0.35–0.40 mm. Septa regularly spaced, 0.40–0.55 mm apart. Free parts concave and perpendicular to long axis. Accretion zone formed by last 6–8 septa because of their thickened mural parts, 2.20–3.15 mm long. Thickening of mural parts occasionally completely fills camerae and endoconic septa with steeply dipping, long mural part form.

Living chamber conical and elongate, distally approaching subcylindrical in shape, proximal end varying in shape depending on type of septa, either being distinctly conical with a pointed end, or blunt with a rounded end. Internal wall surface proximally rather smooth, distally strongly irregular because of well developed annular shelves and only incompletely filled annular concavities. Primary rings with very thick accumulations of lamellae, particularly on inner sides of proximal limbs. Annular shelves mostly at the crests of the rings. Secondary rings with distinct annular shelves proximal in rings and always prosocline. Inward sloping of interspaces reflected on inner side of conch wall.

Primary and secondary shells generally easy to distinguish. Distal rings with some poorly developed pseudopuncta. Thickness of primary shell 0.01–0.02 mm proximally and ca. 0.05 mm distally, secondary shell increasing considerably total thickness of conch wall, particularly in proximal part.

Fig. 44. Odessites inflatus n. sp. ☐ A. Holotype, SMNH X 1361, ×10; Gogs 1, G 73-49 KL. ☐ B. SGU type collection, ×10; Nyan 3, unnumbered SGU sample. ☐ C. Juvenile part with initial chamber, SMNH X 1664, ×40; Hägvide 3, Got 76-10 SB. ☐ D. Lateral view of distal primary and secondary rings, SMNH X 1371, ×75; Botvide 1, MS 218. ☐ E. Longitudinal section of almost complete specimen, SMNH X 1377, ×10; Lunnarna 1, Lu 73-1 KL. ☐ F. Longitudinal section of distal conch wall with aperture, SMNH X 1369, ×75; Fie 1, MS 76. ☐ G. Longitudinal section of septal region, SMNH X 1368, ×150; Tjängdarve 1, MS 261.

Remarks. – *Odessites inflatus* is characterized by the strongly inflated, distal primary rings and by the diffuse cyclic pattern in the early adult part of the conch. There is some variation in the size of the secondary rings within each cycle, especially in the juvenile part of the conch. Thus, a gradual slight increase in size among these rings is not uncommon. The primary rings may be less distinct in the juvenile part of some specimens. The characteristic ring pattern and the nature of the primary rings distinguish this from all other *Odessites* species on Gotland and in Scania.

Occurrence. – *Odessites inflatus* is a common species in the Hemse Beds, from the Hemse Marl, southeastern part up to Hemse/Eke boundary. It has never been found above the latter. In northeastern Gotland its first occurrence is in unit *d* of the Hemse Beds and it becomes the dominant species at the top of the Hemse Beds at e.g. Gogs 1, Botvide 1, Nyan 2 and Gannor 1. In Scania it is confined to the Öved-Ramsåsa Beds, in the lower part of unit *1a*. It is the dominant species at Lunnarna and is rather common at Bjärsjölagård where it was found between 52.60–95.72 m in the borehole Bjärsjölagårdborrningen 1. In the canal at Bjärsjölagård 1 it occurs in beds of the older *Hindeodella steinhornensis scanica* fauna *sensu* Jeppsson (1974) (samples KL 67-31 & -32 LJ). The species occurs in equivalent beds in the Klinta and Ramsåsa areas.

Odessites lauensis n. sp.

Figs. 17C, 23C, 45.

Derivation of name. – Latin *Lauensis,* inhabitant of Lau, referring to the location of the type locality in the parish of Lau, Gotland.

Holotype. – SMNH No. X 1411, Fig. 45A.

Type strata. – Eke Beds, upper part (sample MS 40).

Type locality. – Lau Backar 1, Gotland.

Material. – From the type locality 185 specimens, from additional localities in the Eke Beds, 7 specimens.

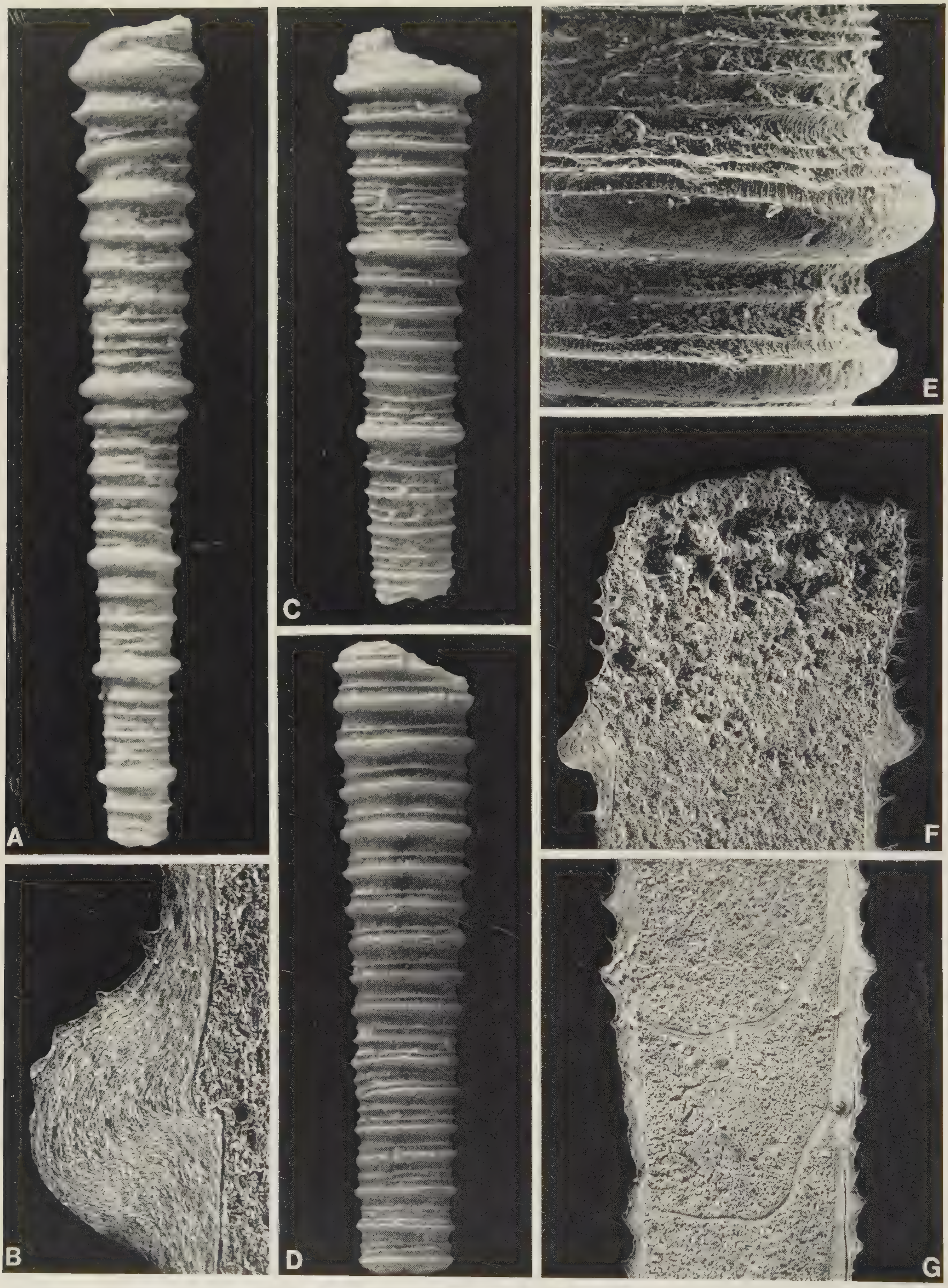


Fig. 45. Odessites lauensis n. sp. A. Lau Backar 1, MS 40. B, F. Lau Backar 1, MS 51. C, E, G. Lau Backar 1, MS 456. D. Lau Backar 1, MS 490. ☐ A. Holotype, SMNH X 1411, ×25. ☐ B. Longitudinal section of primary ring, SMNH X 1409, ×150. ☐ C. Specimen showing distal ring pattern, SMNH X 1413, ×25. ☐ D. Specimen showing a different ring pattern, SMNH X 1415, ×25. ☐ E. Lateral view of primary ring and adjacent secondary ring, SMNH X 1405, ×75. ☐ F. Longitudinal section of last primary ring and aperture, SMNH X 1409, ×75. ☐ G. Longitudinal section of septal region, SMNH X 1406, ×75.

Table 23. Odessites lauensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1411 (holotype)	5.98	0.87	0.47		
SMNH X 1406	4.95	0.55	0.10	0.53	6.5°
SMNH X 1410	3.76	0.61	0.40	0.57	
SMNH X 1413	4.16	0.79	0.53		
SMNH X 1415	4.55	0.83	0.61		
SMNH X 1416	2.45	0.41	0.12		6°
SMNH X 1418	2.73	0.44	0.12		7°

Diagnosis. – Straight *Odessites* of medium size, proximal part expanding at 5–6.5°, distal part subcylindrical. Proximal annulation of regularly spaced rings, separated initially by smooth concave interspaces but more distally with one annulet in each interspace. Distal annulation of widely spaced, asymmetrical primary rings with 4 or 5 secondary rings in each primary interspace. Few annulets. Proximal part with free, strongly irregular septa. Living chamber with mostly smooth inner wall surface, only slightly irregular distally. Few pseudopuncta.

Description. – Conch straight, proximal part expanding at 5–6.5°, distal part becoming more or less subcylindrical. Conch of medium size, estimated length 11–14 mm. Initial chamber unknown. Minimum outer proximal diameter 0.10 mm, distal outer diameter usually 0.80–0.85 mm. Aperture perpendicular to long axis.

Ornamentation with two types of ring patterns, both perpendicular to long axis. Proximally, up to a conch diameter of ca. 0.45–0.55 mm, annulation of rings increasing gradually in size and spacing in a distal direction. Most proximal rings separated by smooth interspaces, more distally, in the juvenile part, one or, occasionally, two annulets occur in interspaces. First annulets generally appearing at an outer conch diameter of ca. 0.25 mm. Density of rings 8 per mm proximally, 5–6 per mm in the region of the last septum. Second ring pattern cyclic primary rings spaced at intervals of 1.20–1.35 mm, rings increasing somewhat in size towards distal end. Between primary rings 4 or 5 regularly spaced secondary rings, generally somewhat distal within each cycle, producing a longer secondary interspace between primary ring and next secondary ring. Secondary rings of equal size, mostly alternate with one annulet, occasionally 3–5 annulets, especially in the most distal part of the conch. When there is only one annulet, it lies in the proximal half of each secondary interspace. Early part of distal ring pattern commonly varying; with weakly developed primary rings occasionally being difficult to distinguish from secondary rings. Thus, the ring pattern consists of secondary rings alternating regularly with annulets. This pattern may extend up to a conch diameter of 0.75 mm.

Primary rings asymmetrical displaying opisthocline and slightly opisthocyrt axial traces. Hinge line occasionally proximal to crest. Many rings with diffuse axial trace in the outer part of the ring occasionally vanishing completely because of hemispherical outermost laminae. Hinge line mostly clearly marked, crest gently rounded. Profile of rings almost bi-convex, convexity of the two slopes different, proximal slope having a stronger convexity while distal slope is flatter and frequently concealed by coarse annulets. Proximal slopes always smooth. Height of distal primary rings 0.14–0.18 mm, height: basal width about 1: 2.

Secondary rings asymmetrical, becoming gradually more pronouncedly so in the distal part. Proximal rings low, displaying a convexo-concave profile with a sharp hinge line slightly distal to crestal line. Distal secondary rings distinctly convexo-concave with marked hinge lines forming the crestal lines of the rings. Rings with prosocline, prosocyrt axial traces in the innermost part of the rings becoming almost perpendicular to long axis. Height of rings 0.07 mm close to distal part of conch. Proximal side always smooth, distal slope with one annulet in transition between ring slope and next interspace.

Annulets appearing in secondary interspaces extending onto distal slopes of rings, on primary rings almost up to their crestal line. Annulets generally having a prosocline and prosocyrt attitude occasionally orthocline and straight. Some specimens even with opisthocyrt annulets at the extreme distal end. These annulets appear coarser and blunter than the earlier annulets, which are thin and very acute. Height of annulets ca. 0.02 mm proximally and 0.05–0.07 mm distally.

Whole conch with distinct lirae, occurring in tertiary interspaces, crossing annulets but not the rings. Lirae occurring only on distal slopes. Spacing of lirae 5–6 per 0.1 mm.

Secondary interspaces generally flat or weakly concave, tertiary interspaces always distinctly concave.

Proximal septal region with free septa spaced well apart, at intervals of 0.45–0.60 mm, last septum occurring at an outer conch diameter in adult specimens of 0.55–0.60 mm. Total number of septa unknown, but is estimated at about 10–12. Septa mostly oblique, free parts concave and irregular. Each septum having the same shape and attitude as the one before. Mural parts comparatively long.

Living chamber subcylindrical with an obtuse and wide proximal end. Wall surface comparatively smooth, with minor annular concavities distally. Concavities asymmetrical with steep proximal sides and gently sloping distal sides, annular shelves narrow. Proximal limbs of primary rings greatly thickened and annular shelves approximately at the level of the crests of the rings. Annular shelves far proximal in secondary rings.

Proximal limbs of rings exhibiting few, rather poorly developed pseudopuncta. Traces of pseudopuncta occasionally seen in distal limbs. Thickness of primary shell 0.02–0.03 mm in the septal region and 0.05–0.06 mm distally. Thickness of proximal secondary shell about the same as that of primary shell, but distally half or less of the thickness.

Remarks. – *Odessites lauensis* is characterized mainly by its distal ring pattern and the strongly asymmetrical septa. The distal ring pattern has some resemblance to that of *Odessites prolatus* but the latter species has wider primary interspaces and more annulets in the secondary interspaces. Internally there are great differences in the septal arrangement, *Odessites lauensis* having septa with much thinner mural parts and more irregular free parts.

Odessites lauensis shows some variation in the size of the primary rings in the distal ring pattern. The number of annulets in the secondary interspaces may vary from one to several.

Occurrence. – *Odessites lauensis* is typical of the upper Eke Beds where it seems especially abundant in the *Rhizophyllum* Marl. Some proximal parts which are tentatively referred to this species have been found in the lowermost Burgsvik Beds at Glasskär 1. Questionable specimens have been found at Petsarve 1, so it is possible that the species appears in the middle Eke Beds.

Odessites lebiensis (Zagora 1972)

Figs. 11H–J, 46.

Synonymy. – ☐ *Tentaculites tenuis* Sowerby–Moberg & Grönwall (1909: 46, Pl. 2: 2a–b). ☐ *Tentaculites lebiensis* n. sp. – Zagora (1972: 1196–1199, Figs. 1–9). ☐ *Tentaculites lebiensis* Zagora, 1972 – Hajłasz (1974: 476, Pl. 11: 8).

Holotype. – Specimen in Zagora (1972, Fig. 2).

Type stratum. – Borehole Leba 1, depth 686.4 m (i.e. the zone with *Neobeyrichia incerta* and *Acastella prima, sensu* Tomczykowa & Witwicka (1974).

Type locality. – Borehole Leba 1, at Łeba, North Poland.

Material. – About 95 specimens from the Öved-Ramsåsa Beds units *3* and *4 sensu* Grönwall (1897).

Diagnosis (emended). – Narrow *Odessites* with a proximal growth angle of 5–8.5°, distal growth angle 2–4°. Conch straight, proximal part occasionally with slight curvature. Primary rings widely spaced, alternating with groups proximally of 2–8 secondary rings, distally of 3 or 4. Secondary rings of equal size or size gradually increasing within each cycle. Annulets numerous in secondary interspaces and on distal slopes of the primary rings, cuspate and separated by concave interspaces. Proximal part with free, asymmetrical septa, distally an accretion zone. Living chamber with slightly irregular inner wall surface. Pseudopuncta not developed.

Description. – Conch slender, proximal part expanding at 5–8.5°, distal part at 2–4°. Conch straight except for the very proximal part which may be slightly curved. Length of fully adult specimens 11–13 mm. Initial chamber unknown. Minimum outer proximal diameter 0.12 mm, outer distal diameter in fully adult specimens 0.90–0.95 mm. Aperture perpendicular to long axis.

Annulation perpendicular to long axis consisting of primary and secondary rings arranged in a rhythmic pattern. Most proximally annulation comprising only one type of rings, gradually increasing in size and spacing towards the first primary and generally formed at an outer conch diameter of 0.40–0.55 mm, occasionally of 0.65 mm. Rings immediately before the first primary ring commonly somewhat larger than those before. Density of rings immediately before the first primary ring 10–14 per mm. Rings low and symmetrical with a bi-convex profile. Total length of juvenile conch up to the first primary ring up to 4 mm.

Primary rings of distal ring pattern occurring at regular intervals. First two rings usually 1.10–1.30 mm apart, but spacing may be smaller, 0.90–1.00 mm, or larger, 1.60–1.80 mm, most distal primary rings occurring ca. 1.60–1.90 mm apart. Primary interspaces proximally with 2–8 secondary rings, distally 3 or 4. Rings commonly equal in size but occasionally showing a gradual distal increase in size within each cycle. Numerous, regularly spaced annulets occurring between rings and on distal slopes of the primary rings. Number of annulets on the latter, 2–3.

Primary rings slightly asymmetrical with an opisthocline attitude, axial traces somewhat opisthocline and straight, vanishing towards the crest of the rings because the laminae there are hemispherical. No hinge line developed. Profile of rings bi-convex with rounded or somewhat flattened crests, proximal slopes smooth while distal slopes have 2 or 3 annulets. Height of the most distal rings ca. 0.1 mm, height: basal width about 1: 2.5.

Secondary rings attaining an asymmetrical and prosocline attitude with prosocline and prosocyrt axial traces. Well defined hinge lines, commonly forming crestal lines. Profile of rings convexo-concave.

Annulets small and symmetrical with a cuspate profile, separated by concave interspaces, secondary interspaces also concave.

The material available has not permitted lirae to be studied because most conchs have abraded surfaces.

Table 24. Odessites lebiensis (Zagora) (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WFCY	WLCY	PA
SMNH X 1623	8.80	0.76	0.20	0.44		1.24	1.80	8°
SMNH X 1627	6.88	0.72	0.18	0.64	0.36	1.60	1.60	7°
SMNH X 1630	7.40	0.84	0.24	0.56	0.48	1.28	1.36	7°
SMNH X 1637	10.52	0.92	0.24	0.40		1.20	1.80	5°
SMNH X 1638	10.36	0.80	0.26	0.44		1.12	1.28	6°
SMNH Mo. 4769	11.80	0.88	0.16	0.40		0.96	1.32	5°
LO 4886 t	7.52	0.92	0.12	0.36		1.12	1.52	6°
SGU Te 15	6.96	0.72	0.18	0.56		1.80	1.64	7°

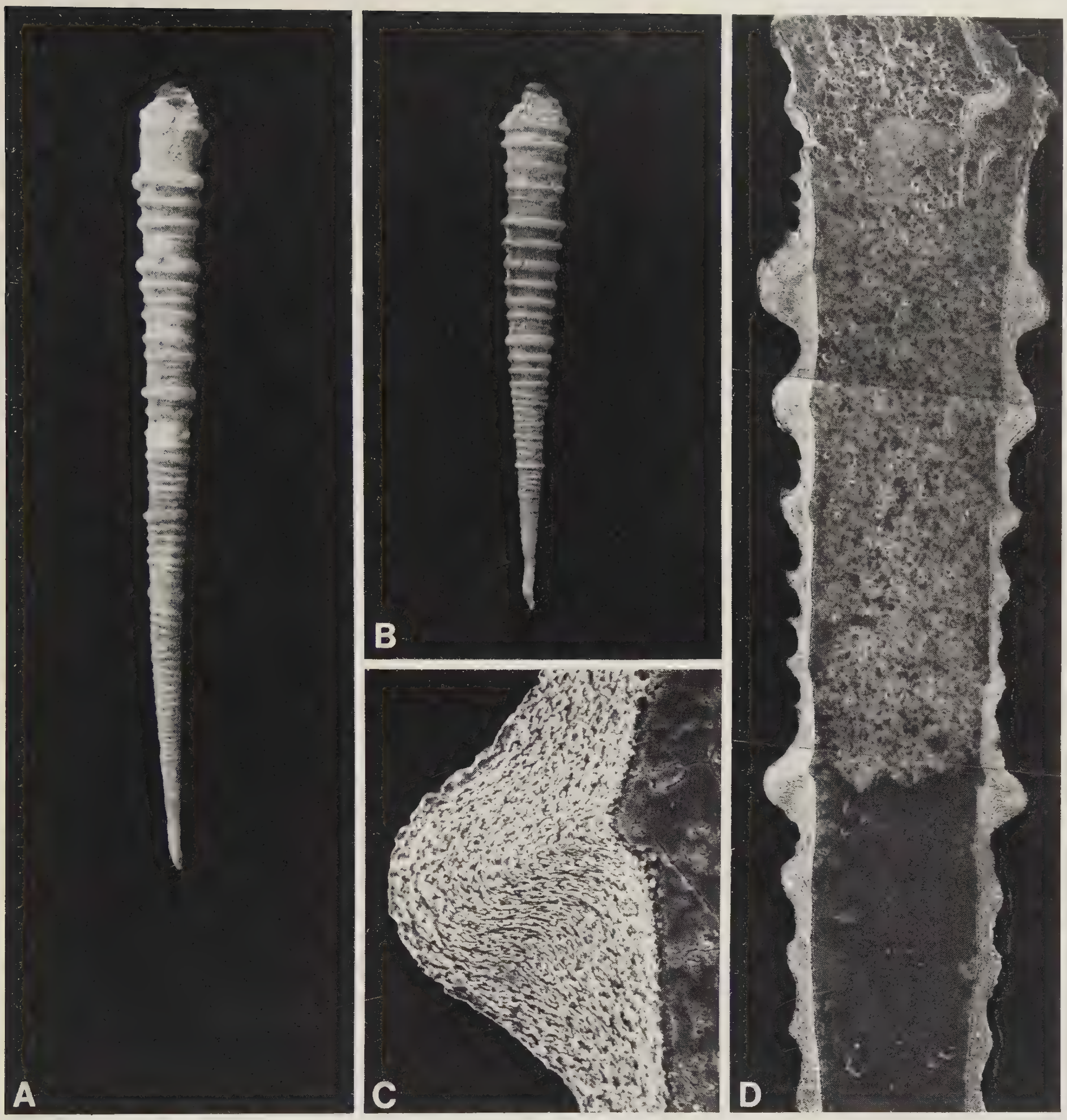


Fig. 46. Odessites lebiensis (Zagora). ☐ A. Almost complete specimen, SMNH Mo. 4769, × 10; "Ramsåsa", unnumbered SMNH sample. ☐ B. LO 4886t, × 10; Ramsåsa 1, unnumbered PDL sample. ☐ C, D. Longitudinal sections of primary ring, × 300, and of living chamber with preserved functional aperture, × 60, SMNH X 1689; Ramsåsa 6, Ra 71-1 KL.

However, there is no reason to believe that lirae are missing.

Proximal septal region with asymmetrical septa, occurring at intervals of 0.10–0.20 mm and occasionally spaced rather irregularly. The most distal 5–7 septa form an accretion zone, often with a length of 1.60–2.00 mm. Last septum occurring at an outer diameter of 0.45–0.50 mm. Free parts of septa concave occurring either perpendicular or oblique to long axis, mural parts strongly asymmetrical.

Living chamber slightly conical and having an asymmetrical proximal part. Internal wall surface slightly irregular with shallow, somewhat asymmetrical annular concavities in primary rings. Concavities slightly distal to crests of rings, annular shelves narrow and prosocline.

Primary and secondary shells easily distinguished. No pseudopuncta found. Thickness of primary shell ca. 0.02–0.03 mm proximally and 0.04–0.05 mm distally.

Remarks. – Odessites lebiensis is recognized by the numerous secondary rings of the early cycles and by the slow increase in size of these rings within each cycle. Commonly, the most distal secondary ring within each cycle is very close in size to the next primary ring.

The proximal ring pattern may sometimes be difficult to distinguish from that of *Lonchidium groenwalli.* The

Table 25. Odessites majstriensis n. sp. (dimensions in nm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WLCY	PA
SMNH X 1565 (holotype)	16.16	0.83	0.10	0.32		1.35	4°
SMNH X 1563	11.96	0.67	0.10	0.26		2.26	4.5°
SMNH X 1564	9.98	0.67	0.12	0.36		1.90	5°
SMNH X 1566	9.42	0.55	0.08	0.16	0.26	1.86	4°
SMNH X 1568	8.00	0.51	0.10	0.26	0.28	1.39	4.5°
SMNH X 1569	12.36	0.68	0.10	0.26		2.06	5°
SMNH X 1570	9.98	0.55	0.16	0.28	0.30	1.78	5°

latter species develops coarse secondary rings immediately before the first primary ring and has many secondary rings in the first primary interspaces. However, the distal ring patterns of the two species are very different.

Occurrence. – Zagora (1972) described *Odessites lebiensis* from the borehole Leba 1 at Łeba, northern Poland, from the interval 665–712 m. This, according to Tomczykowa & Witwicka (1974), corresponds to the zone with *Neobeyrichia incerta* and *Acastella prima* in the Podlasie Beds. Zagora (1972: 1197–1198) pointed out that the species does not occur on Gotland nor in the *Beyrichienkalk* proper. The present study corroborates this statement. The species has only been found in the uppermost two units, *3* and *4*, of the Öved-Ramsåsa Beds of Scania. It is particularly abundant in the lowermost part of unit *3*, e.g. at Skartofta and Vrangelsborg in the grey horizons of the Öved-Ramsåsa Beds. In the borehole Bjärsjölagårdborrningen 2, it occurs at 5.58 m, which is about 5 meters above the unfossiliferous yellow sandstone, unit *2*, of the Öved-Ramsåsa Beds.

Odessites majstriensis n. sp.

Figs. 11A–B, 18D, 47.

Derivation of name. – Latin *Majstriensis,* from Majstre, referring to the type locality for the species.

Holotype. – SMNH No. X 1565, Fig. 47A.

Type strata. – Hamra Beds, unit *b* (sample G 73–71 KL).

Type locality. – Majstre 1, Gotland.

Material. – From the type locality 80 specimens, from other localities in the Hamra Beds 195 specimens; from localities in the Sundre Beds about 150 specimens.

Diagnosis. – Narrow, slender *Odessites,* proximal part expanding at 4–5°, distal part subcylindrical. Conch of medium size. Surface of conch ornamented with regularly spaced primary rings separated by 3–5 secondary rings about of one size. Annulets absent proximally, in the early distal cycles one annulet per secondary interspace, more distally 2–4. Secondary and tertiary interspaces clearly concave. Lirae very distinct. Living chamber long and subcylindrical. Internal wall surface slightly irregular. No pseudopuncta.

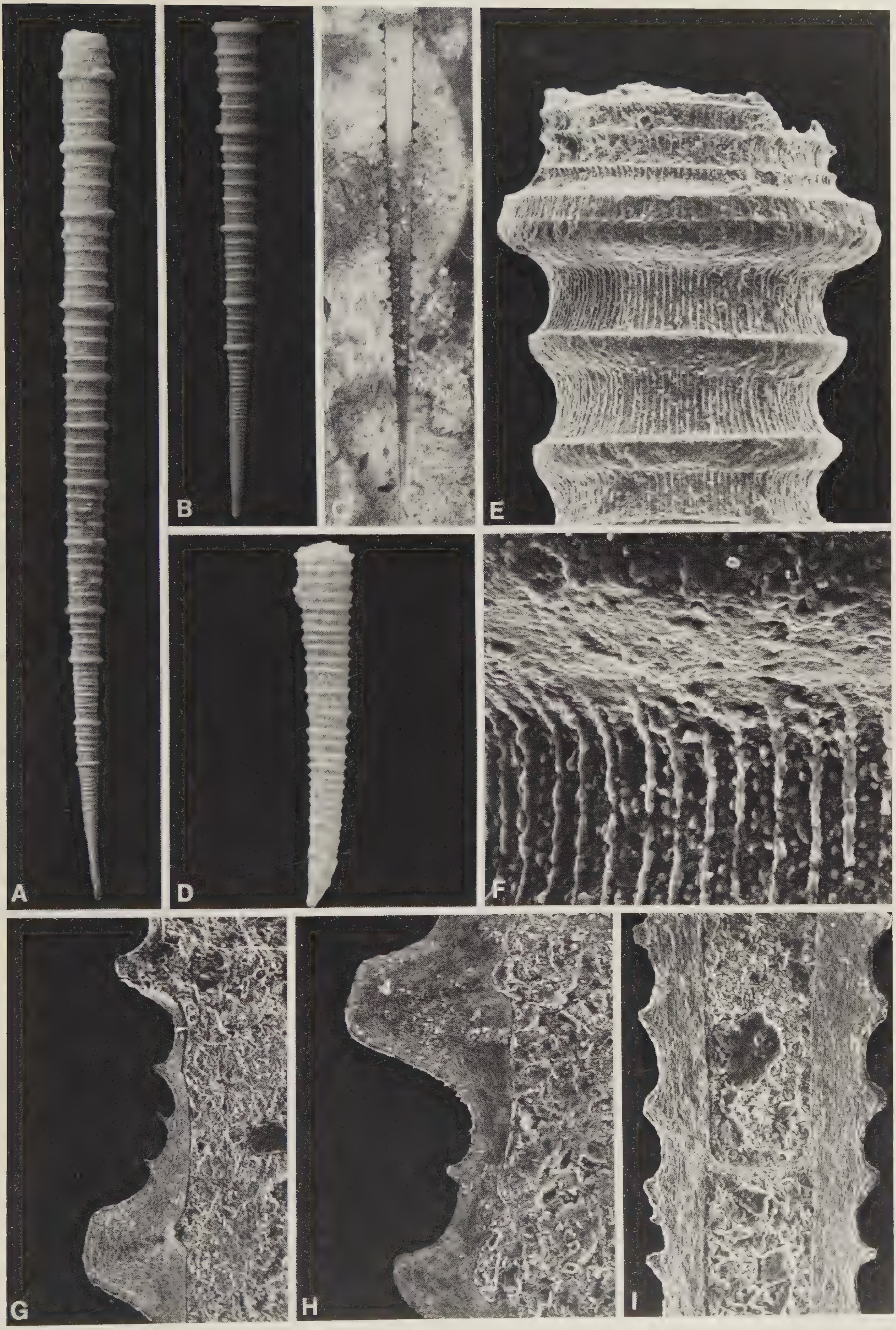
Description. – Conch very narrow and slender, proximal part expanding at 4–5°, distal part subcylindrical. Change of growth angle occurring gradually. Conch straight except for the very early proximal part which commonly shows slight curvature. Fully adult specimens reaching a length of 16–17 mm. Initial chamber clearly bilateral symmetrical. Long axis of chamber deviates distinctly from the axis of the juvenile part. Apical end obtuse. Surface of initial chamber with two oblique, widely spaced rings, interior unknown. Diameter of wide end 0.10 mm. No constriction between initial chamber and juvenile part. Length of chamber 0.25 mm.

Aperture perpendicular to long axis. Outer distal diameter in fully adult specimens 0.80–0.85 mm.

Conch covered by rings and annulets arranged in a cyclic pattern. Extreme proximal part having rings of one size but gradually increasing in size and spacing in a distal direction. The 2 or 3 rings immediately after the initial chamber looking similar to the two embryonic rings of the chamber. Spacing of these 2 or 3 rings wider than for the rings following. Former rings initially showing some obliquity but change and become perpendicular. Density of early juvenile rings 25–30 per mm, decreasing gradually to 10–12 rings per mm immediately before the first primary ring. Juvenile rings asymmetrical with faint prosocyrt axial traces. Profile convexo-concave, hinge line sharp, forming the crestal line of the ring.

Main part of conch having rings arranged in a distinctly cyclic pattern. Primary rings occurring at increasingly wider intervals towards distal end. Fully adult specimens with 11 or 12 primary rings separated by 3–5 secondary rings and a variable number of annulets. Spacing of primary rings initially increasing gradually from 0.50–0.90 mm to 1.50–2.30 mm, most distally becoming fairly uniform at 1.35–1.50 mm. First primary ring appears at an outer conch diameter of 0.24–0.35

Fig. 47. Odessites majstriensis n. sp. A, B, C, D, G, H, I. Majstre 1, G 73-71 KL. E, F. Kättelviken 4, MS 788. ☐ A. Holotype, SMNH X 1565, × 10. ☐ B. Young individual, SMNH X 1564, × 10. ☐ C. Longitudinal section of almost complete specimen, SMNH X 1566, × 10. ☐ D. Lateral view of juvenile part and initial chamber, SMNH X 1575, × 50. ☐ E, F. Lateral view of primary and secondary rings, × 100, and detail of lirae, × 600, SMNH X 1575. ☐ G, H, I. Longitudinal sections of distal conch wall, × 120, of primary and secondary rings, × 150, and of septal region, × 250, SMNH X 1571.


A
B
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mm, occasionally already by a diameter of 0.16 mm. Primary rings slightly asymmetrical. Outermost laminae almost hemispherical, axial trace diffuse. Proximal slopes of rings rounded passing into a rounded crest. Hinge line distinct, occurring distal to crestal line. Distal slopes slightly concave or flat. Height of most distal priamry rings 0.12–0.14 mm, height: basal width about 1: 2.

Secondary rings occupying primary interspaces, initially 4 or 5, more distally 2–5 rings per interspace. Secondary rings of two first primary interspaces generally slimmer than subsequent rings. Often, these interspaces entirely lack annulets. Secondary rings distinct and regularly spaced between primary rings from the third interspace, or at a conch diameter of ca. 0.34–0.35 mm. Secondary interspace immediately after primary ring often wider than those between subsequent secondary rings. Up to a conch diameter of ca. 0.60 mm there is always only one annulet between secondary rings. Subsequently, normally 2–4, occasionally 7 or 8, annulets occur in each secondary interspace. Secondary rings clearly asymmetrical with slightly prosocyrt axial traces. Profile convexo-concave, crests rounded. Hinge line well defined, sometimes forming the crest of the ring but normally occurring distal to crest.

Annulets clearly prosocyrt having wide bases and thin, sharp crests, occurring in secondary interspaces. A single ring also occur far down the distal slope of the primary rings.

Primary interspaces flat, secondary and particularly tertiary interspaces concave.

Lirae well defined in the tertiary interspaces, in the secondary interspaces which have no annulets and in the crestal furrow on the primary rings. Occasionally, weak traces of lirae proximal to the crestal line may be observed. Major part of proximal slopes always without lirae. Density of lirae mostly 7–8 per 0.1 mm.

Proximal septal region with well spaced septa. Last septum is at a conch diameter of 0.26–0.30 mm, in the material sectioned. However, the conchs sectioned are all relatively young individuals and the last septum in fully adult specimens should probably be more distal. All septa free and thin, occurring at intervals between 0.30–0.60 mm, free parts straight or slightly concave.

Living chamber long and subcylindrical except for the early proximal part which is slightly conical. Internal wall surface slightly irregular because of incompletely filled annular concavities. Annular shelves of primary rings shallow and generally rather central within rings, annular concavities consequently shallow and very narrow, often symmetrical. Secondary rings having comparatively wide annular concavities reflecting roughly external shape of rings.

No pseudopuncta observed. Proximally primary and secondary shells relatively easy to distinguish. Distally distinction less obvious. Thickness of primary shell 0.01–0.02 mm proximally increasing gradually to 0.03–0.04 mm distally.

Remarks. – *Odessites majstriensis* is characterized mainly by the relative regularity of the rings, the narrow proximal part of the conch and slender subcylindrical distal part. The distinct lirae and the ornament on the primary rings are other significant characters. *O. majstriensis* shows similarities in the general arrangement of the rings to several other *Odessites* species on Gotland and in Scania. It differs from *O. prolatus* in having a much slenderer conch, shorter primary interspaces and thinner rings; from *O. lauensis* in having shorter primary interspaces and different distal slopes of the primary rings. It has some similarities distally to *O. petilus*, but has shorter primary interspaces and a different arrangement of the rings in the juvenile and early adult parts of the conch. Compared to *O. inflatus* it has much thinner rings, especially the primary rings which also have different distal slopes.

The external characters of *O. majstriensis* show some variability, especially in the spacing of the primary rings, the position of the first primary ring, the number of secondary rings per cycle and the number of annulets per secondary interspace. Internally, the variation is less and affects only the general shape and position of the septa.

Occurrence. – *Odessites majstriensis* occurs in beds from unit *b* of the Hamra Beds up to the basal Sundre Beds. It is the dominant species in units *b* and *c* of the Hamra Beds. It has not been recorded outside Gotland.

Odessites petilus n. sp.

Figs. 7C, 48.

Derivation of name. – Latin *petilus*, thin, slender, referring to the slender nature of the conch.

Holotype. – SGU type collection, Fig. 48A.

Type strata. – Öved-Ramsåsa Beds, unit *1a* (level 80.10–80.20 m).

Type locality. – Borehole Bjärsjölagårdborrningen 1, Scania.

Material. – From the type locality 20 specimens, from additional localities in the Öved-Ramsåsa Beds 10 specimens.

Diagnosis. – Narrow, *Odessites* with a proximal growth angle of 2–3.5°, distal part subcylindrical. Exterior ornamented, proximally with secondary rings separated by interspaces without annulets, distally with widely spaced primary rings separated by regular secondary rings and annulets. Proximal part with numerous septa, most distally forming a prominent accretion zone. Living chamber long. Internal wall surface of most of living chamber smooth,, distally slightly irregular. No pseudopuncta.

Description. – Conch very narrow, proximal part expanding at 2–3.5°, distal part more or less subcylindrical. Change in growth angle gradual. Conch straight except for the extreme proximal end which occasionally shows slight curvature, medium sized, fully adult specimens

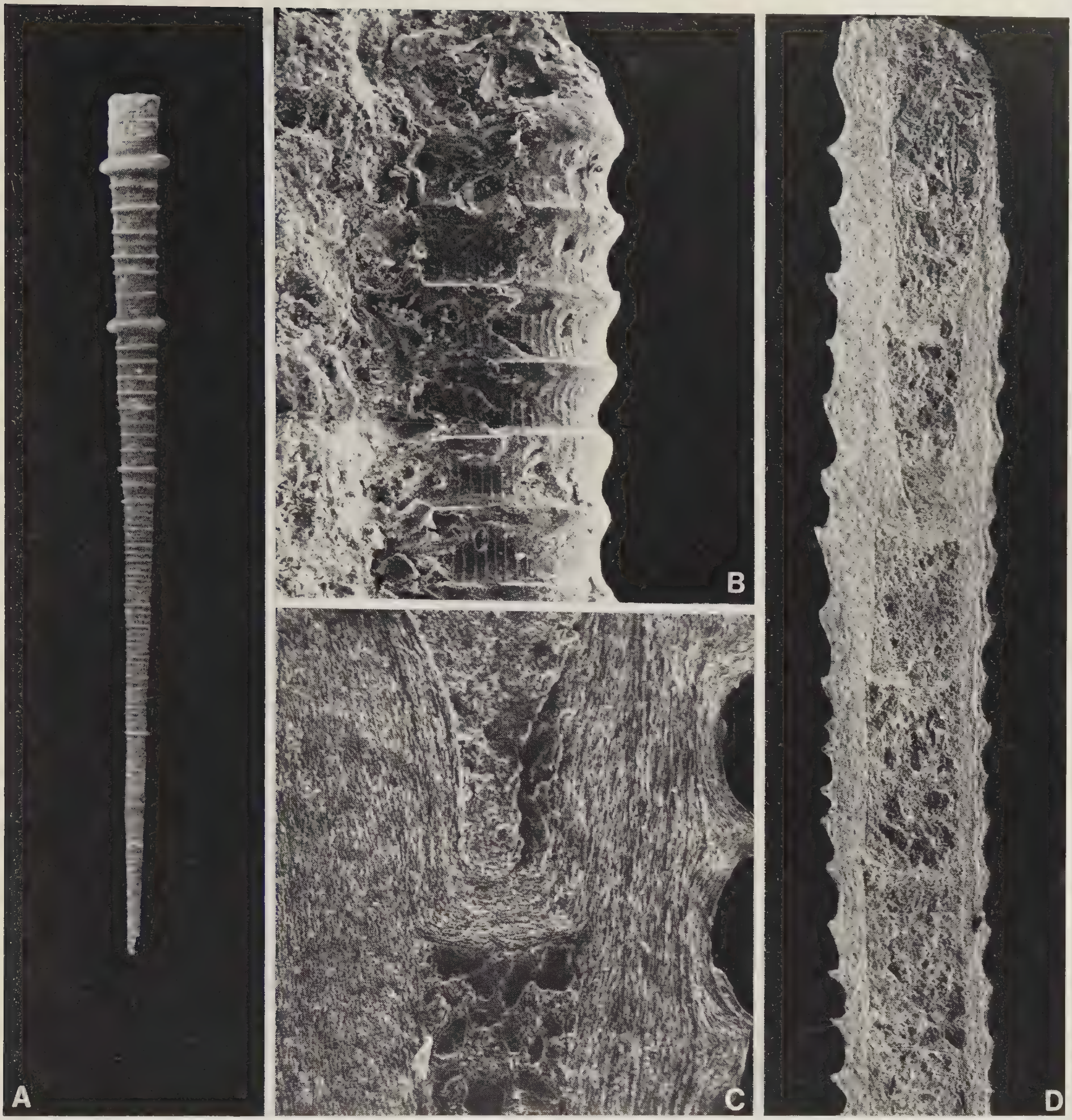


Fig. 48. Odessites petilus n. sp. ☐ A. Holotype, SGU type collection, ×10; Bjärsjölagårdsborrningen 1, 80.10–80.20 m. ☐ B. Lateral view of juvenile part, SMNH X 1402, ×75; Lunnarna 2, Lu AM-2. ☐ C. Longitudinal section of last septum, SMNH X 1692, ×150; Lunnarna 1, Lu AM-1. ☐ D. Longitudinal section of septal region, SMNH X 1401, ×75; sample as for B.

Table 26. Odessites petilus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WLCY	PA
Holotype	12.47	0.79	0.14	0.51		2.53	3°
SGU Te 6	13.78	0.75	0.18	0.48	0.48	2.67	2.5°
SGU Te 8	11.88	0.75	0.24	0.48		2.30	3°
SGU Te 9	12.43	0.91	0.20	0.48		2.30	3°
SGU Te 10	8.67	0.55	0.16	0.48	0.42	1.96	3.5°
SGU Te 11	8.91	0.67	0.32	0.51		2.53	3°
SMNH X 1398	11.00		0.10	0.51	0.44	1.94	3°

reaching a length of 13–14 mm. No fully preserved initial chamber has been available but, judging from a fragmentary specimen, it seems to be conical and pass directly into the juvenile part. Minimum proximal outer diameter generally 0.10 mm, outer distal diameter 0.75–0.95 mm. Aperture perpendicular to long axis.

Conch ornamented with rings and annulets arranged in two principal ring patterns. About half the conch, including the proximal part and early distal part, has secondary rings which increase gradually in size and spacing in a distal direction. Rings separated by interspaces entirely lacking annulets. Occasionally, one or two larger secondary rings may occur in this part of the conch, particularly the very early portion. Density of rings proximally 13–18 rings per mm, immediately before the first primary ring 7–8 rings per mm. Secondary rings asymmetrical with prosocline and slightly prosocyrt axial trace. Profile of rings moderately convexo-concave with a rounded hinge line forming the crestal line.

Second ring pattern developed in distal part of conch with 2 or 3 widely spaced primary rings separated by interspaces having secondary rings and annulets. First primary ring generally formed at a conch diameter of ca. 0.50 mm. Spacing, between primary rings increasing towards distal end 1.90–2.60 mm. Primary rings almost symmetrical with opisthocline and prosocyrt axial trace, profile bi-convex, crests rounded, proximal slopes mainly smooth, while distal slopes have several annulets. Height of most distal primary rings ca. 0.2 mm, height: basal width 1: 2. Secondary rings of distal part of conch occurring 4–8, commonly 6, in each primary interspace separating primary rings. Secondary rings regularly spaced occurring at 4 rings per mm, having an asymmetrical attitude with slightly prosocline and prosocyrt axial trace. Profile convexo-concave or convexo-plane, crests well defined and rounded. Height of rings in the very distal part 0.1 mm, height: basal width 1: 2.

Annulets present only in distal part of conch, occurring between secondary rings, in the early distal ring pattern only one per secondary interspace, later 2–4 per interspace, distal slopes of primary rings also having annulets. Annulets asymmetrical or slightly asymmetrical with a prosocline attitude, height small, 0.02–0.03 mm.

Interspaces generally concave or plane. Slopes of rings passing gradually into interspaces. Sometimes there is a marked difference of slope when the interspaces are flat. Most distal secondary interspaces occasionally sloping slightly inward, but normally the walls of the conch in section are parallel.

Lirae distinct, occupying tertiary interspaces and parts of distal and proximal slopes of rings, lirae comparatively well spaced, 5–6 per 0.1 mm.

Proximal septal region with numerous septa, normally 12–18 septa, the last one at an outer conch diameter of ca. 0.40 mm. Distance from this septum to the first primary ring ca. 1.90 mm. Septa regularly spaced, generally 0.30–0.40 mm apart. Four or five most distal septa considerably thicker than those more proximal and commonly forming an accretion zone. The latter may be composed of 10 septa and has an extension of 5–5.5 mm. Distal septa often asymmetrical. Free parts of septa concave or flat occasionally being oblique, most distal septa having rather narrow and rounded free parts, their mural parts tapering rapidly. Mural part of last septum often extending up to the first primary ring. Proximal septa comparatively thin, having straight or concave free parts perpendicular to long axis.

Living chamber straight and narrow, proximal part rather conical and occasionally slightly asymmetrical depending on the development of last septum. Internal wall surface comparatively smooth along most of the chamber, most distally slightly irregular because of incompletely filled annular concavities. Primary rings having smooth interiors except for the ring closest to aperture which has a wide, well developed annular shelf.

No pseudopuncta observed. Primary and secondary shells easily distinguished. Thickness of primary shell 0.02 mm proximally, 0.03–0.04 mm distally.

Remarks. – *Odessites petilus* is characterized by the very narrow conch, the arrangement of the rings and the long accretion zone. The ring patterns are similar to those of *Odessites prolatus*, but the latter species has a much larger conch, denser lirae and more widely spaced septa. Besides, the septa of *Odessites prolatus* very rarely form an accretion zone.

Occurrence. – *Odessites petilus* occurs in unit *1a* of the Öved-Ramsåsa Beds of Scania. Int he borehole Bjärsjölagårdborrningen 1 it occurs in the interval 48.80–82.80 m. It also occurs in the oldest exposed parts of unit *1a* in the ditch at Bjärsjölagård 1 and in equivalent beds at Lunnarna 2.

Odessites portensis n. sp.

Figs. 8A–B, 23B, 49.

Derivation of name. – Latin *portus*, harbour (Swedish *hamn*), alluding to the type locality at the harbour Ronehamn.

Holotype. – SGU type collection, Fig. 49A.

Type strata. – Burgsvik Beds, lowermost part.

Type locality. – Ronehamn 1, Gotland.

Material. – From the type locality 5 specimens, from additional localities in the Burgsvik Beds 14 specimens, from the Eke Beds 58 specimens and from Scania at the top of unit *1b* of the Öved-Ramsåsa Beds 4 specimens.

Diagnosis. – Medium to large *Odessites* with straight, narrow conch, proximal part expanding at 5–6°, distal part at 1–2°. Annulation of widely spaced, distinct primary rings separated by asymmetrical secondary rings, 6 or 7 proximally, 3–5 distally. Annulets rare proximally, sparse distally. Secondary interspace smooth and concave in juvenile and early adult parts. Living chamber conical, internal wall surface irregular. Pseudopuncta present.

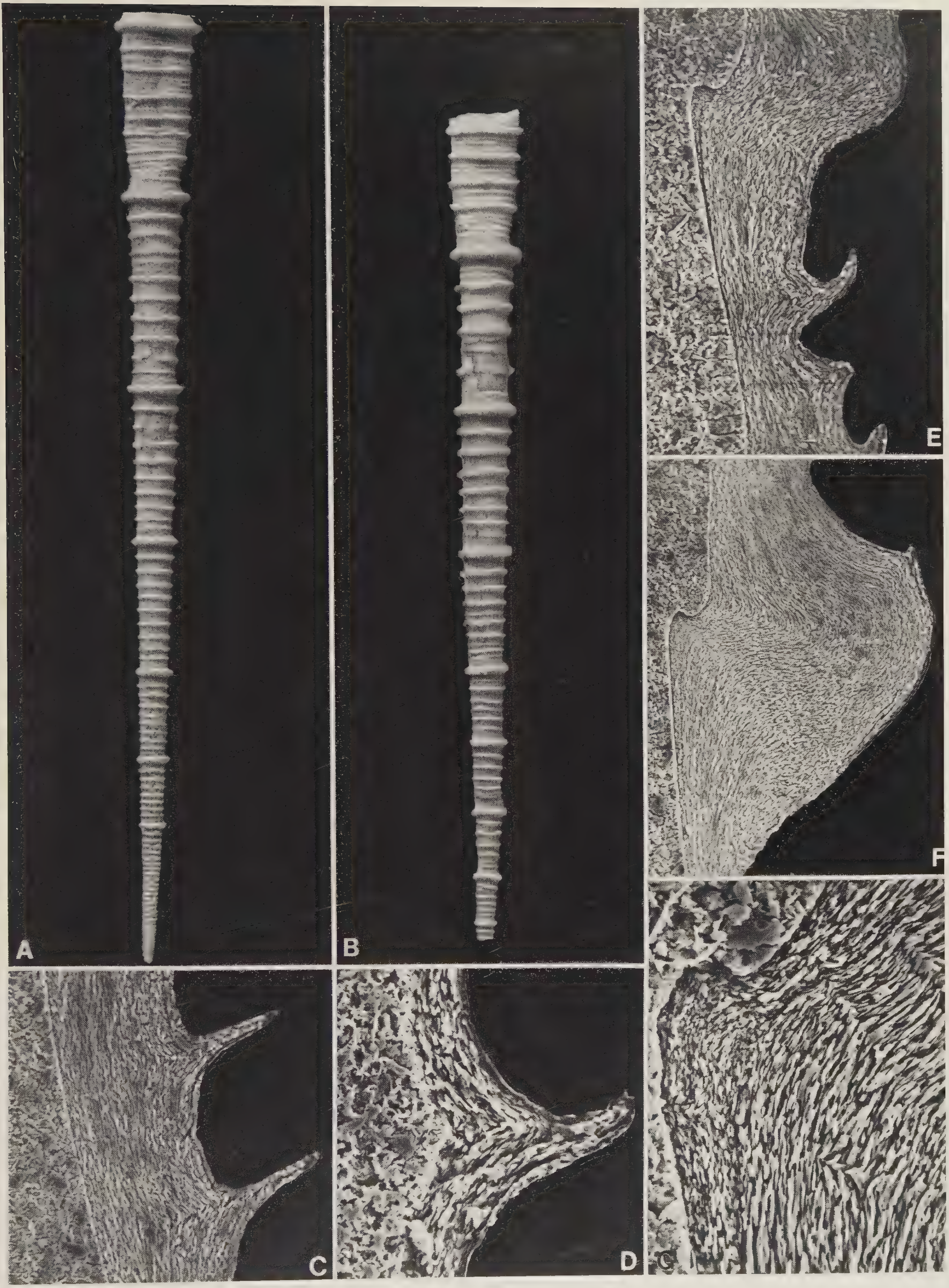


Fig. 49. Odessites portensis n. sp. A, B. Ronehamn 1, unnumbered SGU sample. □ A. Holotype, SGU type collection, ×10, □ B SGU type collection, ×10. □ C, D, E, F, G. Longitudinal sections of distal annulets, ×300, of secondary ring, ×500, of distal conch wall, ×200, of distal primary ring, ×200, and detail of ring in E showing the annular shelf and pseudopuncta, ×750, SMNH X 1688; Klinta 4, Kl 67-32 LJ.

Table 27. Odessites portensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	WFCY	WLCY	PA
Holotype	17.03		0.16	0.38	1.20	3.05	5°
SGU Te 27	12.40	0.74	0.12	0.36	1.16	1.52	5°
SGU Te 28	15.28	1.18	0.26	0.32	0.90	2.89	5°
SGU Te 29	19.00	1.19	0.16	0.30	0.85	2.10	6°
SGU Te 30	12.12	0.87	0.24		1.15	2.22	5.5°
SGU Te 31	12.47	0.75	0.20		1.58	2.45	5°
LR 5	14.80		0.20	0.36	1.26	3.60	
LR 6	14.40	1.00	0.32			2.88	6°

Description. – Conch slim, proximal part expanding at 5–6°, distal part at 1–2°. Conch straight except for the very proximal part which may show slight curvature. Length 19–20 mm. Initial chamber unknown. Minimum outer proximal diameter 0.12 mm, outer distal diameter in fully adult specimens 1.00–1.20 mm. Aperture perpendicular to long axis.

Entire conch except for the very proximal part ornamented with well spaced primary rings, separated by numerous secondary rings. Annulation perpendicular to long axis. Earliest juvenile part having regular rings increasing gradually in size and spacing in a distal direction, density of rings immediately before the first primary ring 10–15 rings per mm. First primary ring occurring at an outer conch diameter of 0.30–0.38 mm. Spacing of first two primary rings varying between 0.90 and 1.60 mm with an average of ca. 1.10 mm. Spacing increasing gradually distally occasionally being 2–3 mm. However, this spacing is variable and may already be 2.70–2.80 mm between the third and fourth, or fourth and fifth primary rings.

Primary rings asymmetrical with a prosocline attitude, outermost part of axial trace prosocline and slightly prosocyrt, inner part opisthocline and straight. Outermost laminae occasionally almost hemispherical. Profile of these rings convexo-concave, crests slightly rounded. Hinge line distinct. Slopes of rings smooth except for the very distal rings which may have one or two annulets on distal slopes. Height of primary rings 0.12–0.14 mm distally, height: basal width 1: 2.0–2.4. Secondary rings occurring in primary interspaces, 6 or 7 proximally and 3–5 distally. Occasionally 9–11 rings occurring in the longest interspace. Size of secondary rings within each cycle very constant. Secondary rings showing similar asymmetry and shape to primary rings. Axial traces less distinct commonly rather straight and slightly prosocline. Annulets rare proximally and in early distal part, but appearing between secondary rings at an outer conch diameter of 0.75 mm, 2 or 3 rings per secondary interspace. In more proximal primary interspaces, annulets are confined to one or two in the earliest portion after the primary ring. Annulets either distinctly proscline and straight attitude or prosocyrt, outer part very thin and pointed.

Primary interspaces flat, secondary interspaces either flat, as in the most distal part of conch, or distinctly concave as found more proximally. Interspaces rather long, almost twice the basal length of the secondary rings.

Lirae present over the entire conch. However, because few conch were available, SEM examination of the detailed morphology was not possible. The shortage of material limited examination of the early juvenile part and thus very little is known of the septal structures. A few fractured conchs show well separated free septa.

Living chamber rather conical and having an irregular wall surface because of incompletely filled annular concavities. Latter concavities strongly asymmetrical. Annular shelves of primary rings rather narrow, frequently showing an opisthocline attitude, situated more or less at same level as crest of the rings. Annular concavities of secondary rings asymmetrical but their annular shelves are far proximal to the crest. Shape of living chamber modified by rather thick accumulation of lamellae around the inner parts of annular shelves and on conch wall proximal to them. Occasionally laminae line the entire conch wall between adjacent secondary rings. Because the crystal tablets are a different size these laminae are easily distinguished from the conch wall.

Conch wall exhibiting very well developed pseudopuncta in the outermost part of proximal limbs of rings. Pseudopuncta well spaced. Weak pseudopuncta occasionally occurring in the distal limbs of rings. Thickness of primary shell ca. 0.03–0.04 mm in distal part of conch.

Remarks. – *Odessites portensis* is characterized particularly by the widely spaced primary rings and the numerous, regularly spaced and equal-sized secondary rings. The smooth, wide secondary interspaces in the juvenile and early distal parts are significant. *Odessites portensis* resembles *O. lauensis* in the general ring pattern, but may be distinguished by having a longer conch, more widely spaced primary rings and smooth secondary interspaces. There are similarities with *O. prolatus,* but the latter species is much larger, shows more annulets per interspaces and develops primary rings later than *O. portensis.*

The ring pattern of *Odessites portensis* may vary rather much in length and number of secondary rings. The internal variation is not known because of the limited material suitable for sectioning.

There is good reason to believe that *Odessites portensis* is one species which has frequently been referred to "*Tentaculites tenuis* Sowerby" in Scania and on Gotland. However, it is evident from the type material of '*Tentacu-*

lites' tenuis Sowerby that this species probably does not occur in Sweden. I emphasize probably because Sowerby's type material is very poorly preserved and is a mould, and thus does not permit safe identification of characters which could be used for the description of this species. Sowerby's type specimen (labelled G.S.M. Geol. Soc. Coll. 6580) is a mould of the proximal and early distal parts of a conch which, judging from the shape of the casts from the annular concavities, shows regularly spaced ring separated by rather wide interspaces. It is not possible to differentiate primary and secondary rings. From a very minute shell fragment preserved on the mould, it seems as if the interspaces have one or two annulets. Among other material labelled *T. tenuis* in the collection of the I.G.S. Museum in London and figured in part by Lardeux (1969, Pl. 13: 6), distal parts are preserved and show regularly spaced primary rings but much closer together than in *Odessites portensis.* This material comes from the Woolhope inlier in the Welsh Borderland, and is also poorly preserved. Thus, it cannot definitively be settled whether or not these belong to *'Tentaculites' tenuis.* It can only be resolved by additional collecting at the type locality at Usk.

Occurrence. – *Odessites portensis* shows a restricted distribution both on Gotland and in Scania. On Gotland it is confined to the uppermost Eke Beds and the lower–middle Burgsvik Beds. Judging from its absence at Lau Backar, it must appear higher than the *Rhizophyllum* Marl. It has been found at one level in the borehole Burgsviksborrningen 1, i.e. 48.95–49.35 m, or 0.25–0.65 m above the Eke-Burgsvik boundary. In Scania a few specimens have been found at Bjärsjölagård 2 and at Klinta 1 in unit *1b* (Grönwall 1897) and unit *2* (Eichstädt 1888) of the Öved-Ramsåsa Beds, respectively.

Odessites prolatus n. sp.

Figs. 11C–D, 50.

Derivation of name. – Latin *prolatus,* elongated, referring to the elongate conch and particularly to the wide spacing of primary rings in the distal portion.

Holotype. – SMNH No. X 1378, Fig. 50A.

Type strata. – Eke Beds, lower part (sample G 72–83 KL).

Type locality. – Hummelbosholm 2, Gotland.

Material. – From the type locality 21 specimens, from additional localities in the Eke Beds 450 specimens.

Diagnosis. – *Odessites* with large, straight conch, proximal part expanding at 4–5.5°, distal part subcylindrical. Annulation of two ring patterns, proximally with regularly spaced secondary rings increasing gradually in size and separated by smooth, concave interspaces, distally with widely spaced primary rings separated by 2–10 secondary rings. Lirae weakly developed. Septa widely and irregularly spaced. Pseudopuncta poorly developed.

Description. – Narrow conch, expanding in proximal part at 4–5.5° and distally at 1–2°, change in growth angle gradually taking place near the first primary ring. Conch straight except for the very proximal part which generally shows slight curvature, large, commonly reaching a length in fully adult specimens of 23–24 mm. Initial chamber unknown. Minimum outer proximal diameter 0.12–0.14 mm, outer distal diameter in adult specimens ca. 1.40 mm. Aperture perpendicular to long axis.

Conch ornamented with rings and annulets perpendicular to long axis, arranged in two principal ring patterns. Proximal part having low secondary rings, increasing gradually in size and spacing, density 15–16 per mm most proximally and 8–10 per mm immediately before the first primary ring. Juvenile rings symmetrical with very elongate slopes, crests rounded. Towards the late proximal part these rings gradually become more asymmetrical with a weak prosocline attitude and convexo-concave profile. Annulets missing between juvenile rings, interspaces smooth and concave. This ring pattern occupies about the first 5 mm of the conch. Next part of conch has widely spaced primary rings and there are secondary rings and annulets in the primary interspaces. Generally, the first 3 or 4 primary rings are more widely spaced than the later rings. Thus the first cycles may be 3.0–3.3 mm wide and the most distal cycles 1.75–2.20 mm. However, there is commonly considerable variation and occasionally the widest cycles are in the distal part of the conch. Number of secondary rings generally 5–7 in wider cycles and 4 or 5 in those narrower. Rings regularly spaced and often increasing gradually in size in a distal direction. Annulets occurring between secondary rings, 1 or 2 in the early distal part and 2–10 in the later part of conch, first two cycles generally lacking annulets. Distal annulets frequently irregularly spaced.

Primary rings symmetrical or slightly asymmetrical with opisthocline, straight axial traces. Rather strongly asymmetrical primary rings occasionally occurring when distal slopes have strongly developed annulets. Profile of rings bi-convex or slightly convexo-concave. Proximal slopes smooth while distal slopes show one or two annulets. Height of primary rings 0.20–0.25 mm, height: basal width 1: 0.5–0.7.

Secondary rings mostly asymmetrical with slightly opisthocline and straight axial traces, profile distinctly convexo-concave.

Distal annulets comparatively well developed, having a prosocline, prosocyrt attitude and narrow, pointed crests. Height up to 0.07 mm but lower, 0.02–0.04 mm in the early distal part.

Secondary interspaces of distal part straight or slightly concave, occasionally sloping inwards slightly. Tertiary interspaces always concave and frequently slightly asymmetrical.

Lirae weakly developed in tertiary interspaces, best in the distal part of conch. Because of unfavourable preservation it has not been possible to study them in the proximal part of the conch.

Proximal septal region: septa widely, rather irregularly spaced, 0.30–1.10 mm apart. Free parts of septa straight or slightly concave mostly perpendicular to long axis

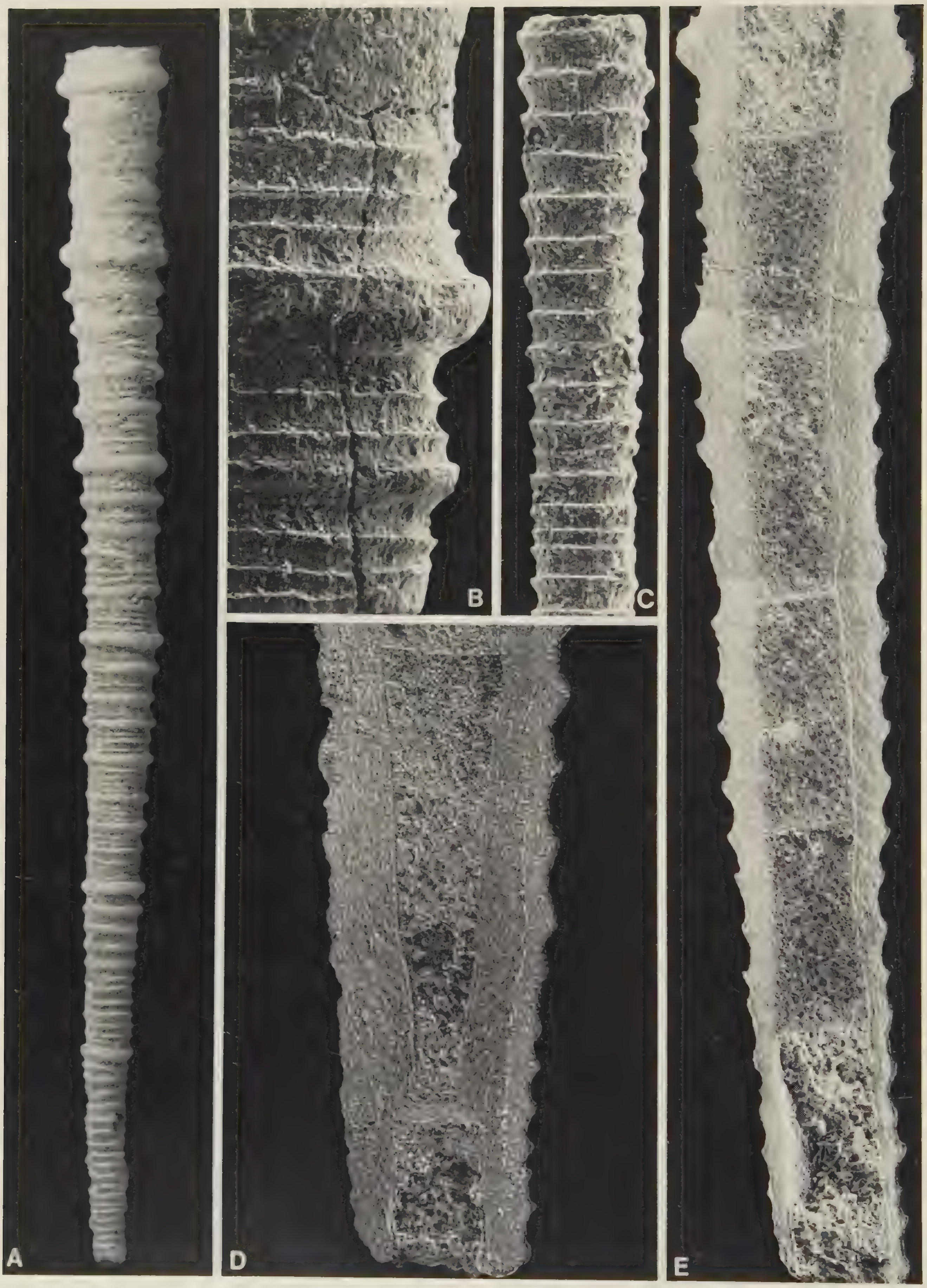


Fig. 50. Odessites prolatus n. sp. A. E. Hummelbosholm 2, G 72–83 KL. B. Kullunde 3, Got 76-30 SB. C. Kullunde 6, Got 76-35 SB. D. Halor 1, MS 313. ☐ A. Holotype, SMNH X 1378, ×15. ☐ B. Lateral view of primary and secondary rings, SMNH X 1690, ×75. ☐ C. Lateral view of juvenile part, SMNH X 1691, ×75. ☐ D. Longitudinal section of distal septal region, SMNH X 1389, ×75. ☐ E. Longitudinal section of septal region, SMNH X 1390, ×60.

Table 28. Odessites prolatus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	WLCY	PA
SMNH X 1378 (holotype)	15.24	1.15	0.30	0.50		2.22	4°
SMNH X 1379	18.33	1.43	0.51	0.69		2.38	4°
SMNH X 1380	14.06	1.38	0.59			1.98	
SMNH X 1381	8.30	0.73	0.22	0.48		0.83	4.5°
SMNH X 1383	11.64		0.14	0.44		2.33	4.5°
SMNH X 1384	13.46	1.35	0.32	0.51		2.22	5°
SMNH X 1385	16.71		0.39	0.51		2.09	5.5°
SMNH X 1388	18.89	1.11	0.48	0.63	0.59	2.42	4°
SMNH X 1403	3.96	0.63	0.50	0.50	0.52	2.38	
SMNH X 1404	4.75	0.65	0.44	0.50	0.50	2.06	

occasionally being slightly oblique. Mural parts symmetrical and persistent, maintaining the same thickness as the free parts for a considerable distance. Most of septa thin but generally the two most distal are significantly thicker so that camerae are very narrow. Last septum occurring at an outer conch diameter in fully adult specimens of 0.50–0.60 mm, i.e. at or slightly after the first primary ring. Total number of septa unknown.

Living chamber long, either subcylindrical or slightly conical, the latter shape most evident in the proximal part of the chamber. Here, the internal wall surface is smooth. Major part of living chamber with an irregular wall surface because of well developed annular concavities being either rounded or angular depending on the shape of the annular shelves.

There are some indications of pseudopuncta in the proximal limbs of the primary rings but these are very slightly developed and not visible in all specimens. Primary shell rather thin, 0.01–0.02 mm in septal region and slightly thicker, 0.02–0.04 mm, distally. However, the total thickness of the conch wall is much greater because the secondary shell increases the wall thickness commonly by 10–15 times.

Remarks. – Odessites prolatus is recognized by the large conch and the typical two-fold ring pattern of a juvenile part showing secondary rings separated by smooth concave interspaces, and an adult part with widely spaced primary rings separated by a variable number of secondary rings. This general type of ring pattern may be seen in *Odessites inflatus* but there are differences in the development of the primary rings and the juvenile parts are very different. The proximal part of *Odessites prolatus* is similar to that of *O. petilus* but there are differences in the development of the septa; *O. prolatus* never has an accretion zone of the type characteristic of *O. petilus.* The latter species has a much slimmer juvenile part.

The distal ring pattern of *Odessites prolatus* may vary to some extent in width of the cycle and the number and distribution of secondary rings in each cycle.

Occurrence. – Odessites prolatus has a stratigraphical range from the lower Eke Beds up to the top of the unit. It is particularly abundant in the lower and middle Eke Beds. It has not so far been found outside Gotland.

Genus *Podolites* Ljashenko 1969

Type species (by original designation). – *Podolites rugosus* Ljashenko 1969; from the Ludlovian of Podolia, USSR.

Species on Gotland. – Podolites hedei n. sp., *P. paeninsulicola* n. sp., *P. ternatus* n. sp.

Diagnosis (emended herein). – Genus of the family Volynitidae with medium-sized, conical conchs, stratight or proximally slightly curved. Proximal part expanding at 6–11°, distal part at 2–4° or occasionally subcylindrical. Initial chamber elongated, slightly drop-like, distinguished clearly from the juvenile part by a faint constriction. Initial chamber bilaterally symmetrical. Aperture perpendicular to the long axis of the conch. Annulation perpendicular or slightly oblique to the long axis. Rings rhythmically arranged, primary rings gradually increasing in size and spacing in a distal direction. Primary interspaces with 1–4, regularly spaced secondary rings which gradually increase in size. Ring asymmetrical and rounded. Annulets developed between and on their distal slopes of rings. Lirae well developed. Proximal part divided internally by septa, free proximally and endoconic distally. Living chamber long with irregular internal wall surface. Pseudopuncta not developed.

Stratigraphical and geographical distribution. – The type species, *Podolites rugosus* Ljashenko, is reported from the Ludlovian Malinovtsy Beds of Podolia. The other species already described, *Podolites peregrinus* Zagora, comes from Pleistocene erratic boulders in northern DDR (Zagora 1974: 1223). On Gotland the genus is represented in the Halla, Klinteberg and Hemse Beds.

Remarks. – Podolites is recognized particularly by its cyclic ring pattern which has 2–5 prominent rings per cycle, and by the rounded shape of the rings which clearly distinguishes this from all other genera with rhythmic ring patterns. It differs from *Volynites* Ljashenko in having annulets on the distal slopes of the rings.

No initial chamber or internal characters were reported from the type species. However, examination of Gotland material has made it possible to include such features in the generic diagnosis which is consequently emended here from the original by Ljashenko (1969: 94).

Table 29. Podolites hedei n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	TNCY	WLCY	NRLC	PA
Holotype	9.00	0.90	0.16	0.22		6	1.92		6.5°
SGU Te 39	9.40	0.88	0.12	0.24		6	2.52		7.5°
SGU Te 40	14.68	1.08	0.14	0.36		7	2.68		9°
SMNH X 1162	10.33	0.95	0.15	0.30		7	2.46	5	8°
SMNH X 1166	8.41	1.00	0.09	0.22		10	1.66	4	8°
SMNH X 1167	4.35	0.70	0.07	0.30		5	1.07	4	10°
SMNH X 1168	7.64	0.81	0.20	0.25	0.63	7	1.70	4	8°
SMNH X 1170	7.53	0.81	0.15		0.67	7	1.70	4	10°

Podolites hedei n. sp.

Figs. 11E–F, 51.

Derivation of name. – In honour of the late Dr. J. Ernhold Hede, 1890–1977, founder of the current stratigraphy on Gotland and collector of the type material of the species.

Holotype. – SGU type collection, Fig. 51A.

Type strata. – Klinteberg Beds, unit *a*.

Type locality. – Dibjärs 1, Gotland.

Material. – 25 specimens from the type locality, 100 specimens from the Halla Beds, 30 specimens from additional localities in the Klinteberg Beds, and 10 specimens from the Hemse Beds.

Diagnosis. – Medium-sized, slender *Podolites* expanding proximally at 6–10°, subcylindrical or slightly conical distally. Annulation rhythmic, 2–4 rings per cycle proximally, 3–5 per cycle along the entire adult part. Distal ring cycles extended. The most proximal secondary interspace of each cycle about twice the width of subsequent interspaces. Annulets numerous.

Description. – Conch, slender, proximal part expanding at a growth angle of 6–10°, distal part subcylindrical or expanding at 1–3°, transition from proximal to distal growth angle gradual. Conch slightly curved proximally displaced from a sagittal plane through the aperture by about 0.5 mm. Entire living chamber straight. Conch medium-sized, estimated full length 11–14 mm.

Initial chamber asymmetrical and elongated, with slightly drop-like shape. Distal limit of chamber rather diffuse, shown only by a slight decrease in the outer and inner diameters of the conch. Distance from apex ca. 0.16 mm. Outer diameter at this point 0.07 mm.

Aperture perpendicular to long axis, outer distal diameter in mature specimens 0.95–1.00 mm, occasionally reaching 1.10 mm.

Entire surface of conch ornamented with rings and annulets perpendicular or occasionally slightly oblique to long axis of conch. Rings spaced and the same size at extreme proximal part. First primary ring appearing at an outer conch diameter of 0.22–0.36 mm, subsequent rings grouped in distinct cycles, proximally 2–4 rings per cycle, distally 4–5. Size and spacing of primary rings increasing towards distal end. Spacing increasing from 0.4 mm in septal region to 1.7–2.7 mm in distal part of living chamber. First two or three cycles having similar widths followed by a marked increase in width in subsequent cycles in several specimens at a conch diameter of ca. 0.35 mm. Secondary rings within each cycle regularly spaced. Space between primary ring and the first secondary ring of the following cycle generally twice that between secondary rings. Size of secondary rings gradually increasing within each ring cycle. Most proximal rings fairly symmetrical with bi-convex or more or less planar slopes, crests rounded. Last juvenile rings and all distal rings clearly asymmetrical with steep proximal slopes. Axial traces opisthocline and slightly opisthocyrt. Rings bi-convex in profile with rounded crests. The height: basal width 1: 3–1: 4. Secondary rings occasionally approaching triangular in profile.

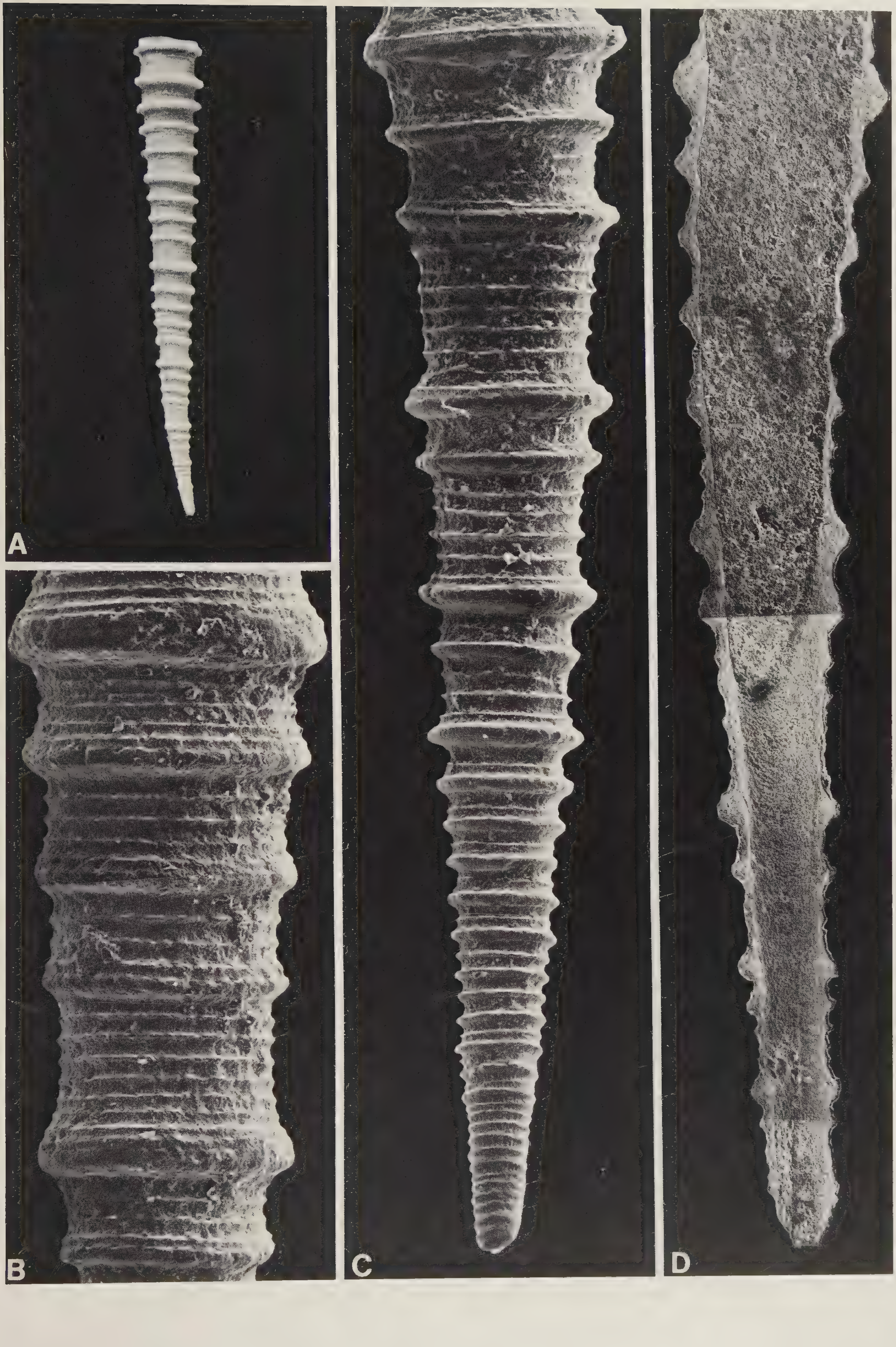
Annulets distinct and evenly spaced in all interspaces and on distal slopes of rings. Annulet closest to the crest often prominent. Tertiary interspace proximal to this annulet strongly concave producing a distinct crestal furrow. Number of annulets 5–8 in the proximal, wide interspace of each cycle, 3–5 in the distal interspaces. Number variable in many specimens even of adjacent cycles. Annulets narrow and pointed with a prosocline attitude.

Interspaces plane or sometimes slightly concave. Width of interspaces increasing gradually towards the distal end. Distally, interspaces often sloping inwards gradually towards long axis.

Lirae developed along entire conch, occupying tertiary interspaces, crossing annulets but never rings, density approximately 12–15 per 0.1 mm in juvenile part, about 20–25 per 0.1 mm distally.

Proximal septal region: septa thin straight, symmetrical and free in extreme proximal part, asymmetrical, in densely stacked endocones distally. Endocones frequently reaching a length of more than 1.0 mm. Apices

Fig. 51. Podolites hedei n. sp. ☐ A. Holotype, SGU type collection, × 10; Dibjärs 1, unnumbered SGU sample. ☐ B. Lateral view of adult part, SMNH X 1179, × 60; Gothemshammer 1, G 72-104 KL. ☐ C. Lateral view of juvenile part, SMNH X 1180, × 75; Gothemshammar 1, MS 669. ☐ D. Longitudinal section of septal region, SMNH X 1182, × 60; sample as for B.


A
B
C
D

of endocones asymmetrical in relation to long axis, sometimes close to conch wall. Last endocones occurring at an outer conch diameter of ca. 0.65–0.70 mm in mature specimens, short, not exceeding the width of a ring cycle.

Living chamber subcylindrical with an asymmetrical, gently rounded proximal end. Internal wall surface distinctly irregular, reflecting the general shape of the exterior. Proximal limbs always heavily thickened with many lamellae stacked inwards forming pronounced annular shelves, sometimes becoming opisthocline in attitude, especially in the most distal part of the conch. Annular shelves far distal to crests of rings.

Secondary shell clearly distinguished from primary shell both in juvenile and in adult parts. Thickness of primary shell increasing gradually from 0.02–0.03 mm proximally to 0.05–0.07 mm distally. No pseudopuncta observed.

Remarks. – *Podolites hedei* is recognized mainly by its comparatively slender form, its extended ring cycles which have a markedly wider secondary interspace in the proximal part of each cycle, and the number of rings per cycle in the adult part. The juvenile part resembles that of *Podolites ternatus,* but *P. hedei* may be distinguished from the former species in having a slenderer proximal part, less densely packed ring cycles, and by the wider secondary interspaces in the proximal part of each cycle. The species differ in the shape of the rings. *Podolites hedei* is very similar to *P. peregrinus* Zagora. However, the latter species shows denser primary rings proximally and the secondary rings within each cycle tend to increase in size more rapidly. The shape of the primary rings is dissimilar, particularly distally where in *Podolites peregrinus* they have long, convex distal slopes. Compared to *P. peregrinus, P. hedei* shows few annulets in the interspaces or on the distal slopes of the primary rings.

Some variation has been observed in *Podolites hedei* in the general arrangement of rings. Thus, rings in some specimens are slightly oblique although the majority in populations has rings perpendicular to the long axis. In some specimens the distal slopes of rings pass gently into the following interspace without any marked boundary between the ring and the interspace. There is some variation in the curvature of the proximal part of the conch.

Occurrence. – *Podolites hedei* occurs on Gotland from the Halla Beds, unit *c* up to the Hemse Beds, unit *c.* It reaches its greatest abundance in the Halla Beds and in the basal parts of unit *a* of the Klinteberg Beds. It is not known outside Gotland.

Podolites paeninsulicola n. sp.

Figs. 22, 52.

Synonymy. – □ *Tentaculites* (s.l.) n. sp. a – Zagora, 1974: 1224–1225, Pl. 2: 1–2.

Derivation of name. – Latin *paeninsula,* peninsula and *-cola,* dweller, referring to the Östergarn peninsula where is the type locality and from where derives most of the material examined.

Holotype. – MB.1974.15a, figured by Zagora (1974, Pl. 2: 1); in this paper figured in Fig. 52A.

Type strata. – Hemse Beds, unit *c.*

Type locality. – Hammarudden 1, Gotland.

Material. – From the type locality 5 specimens, from additional localities in the Östergarn area 130 specimens.

Diagnosis. – Medium-sized *Podolites* with straight conch, proximal part expanding at 5–9°, distal part at 3–4°. Aperture perpendicular to the long axis. Ring cycles with 3–6, symmetrical or slightly asymmetrical, well-defined, high rings. Living chamber conical with internal wall surface smooth proximally, slightly irregular distally.

Description. – Slender conch, proximal part expanding at 5–9°, distal part at 3–4° or sometimes approaching subcylindrical. Conch straight, extreme proximal end occasionally slightly curved. Length of fully mature specimens 17–21 mm. Initial chamber unknown. Minimum outer proximal diameter 0.06 mm, outer distal diameter in fully adult specimens 1.10–1.30 mm. Aperture perpendicular to long axis.

Whole conch ornamented with rings and annulets perpendicular to long axis of conch. Rings having a cyclic pattern along the entire conch except for the very proximal, curved part, exhibiting only densely arranged rings

Table 30. Podolites paeninsulicola n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	TNCY	WLCY	NRLC	PA
MB. 1974. 15a (holotype)	19.01	1.27	0.16		12	2.69	5	5°
MB. 1974. 15b	14.06	1.11	0.36		8	2.49	5	5°
SMNH X 1198	11.88	1.18	0.22	0.42	11	1.55	3	7°
SMNH X 1199	7.12	0.88	0.11	0.44	8	0.92	3	8°
SMNH X 1200	11.73	1.20	0.15	0.46	10	2.18	3	9°
SMNH X 1201	11.44	1.00	0.13	0.42	9	1.59	3	7°
SMNH X 1213	15.50	1.29	0.33	0.63	12	1.66	3	
SMNH X 1215	10.07	1.00	0.35	0.55	8	1.29		

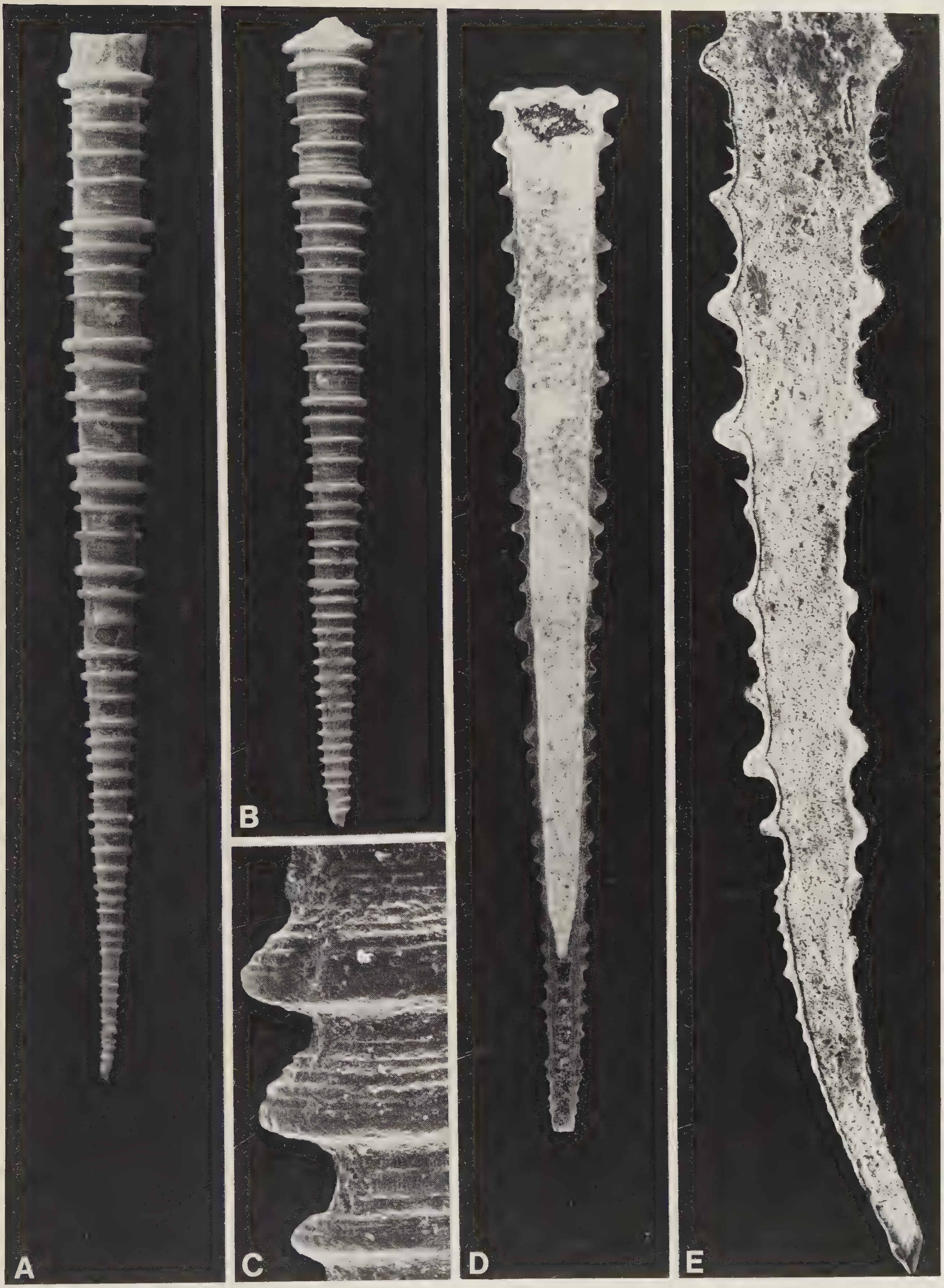


Fig. 52. Podolites paeninsulicola n. sp. ☐ A. Holotype, MB. 1974. 15a, × 10; Hammarudden 1. ☐ B. Specimen from some slab as holotype, MB. 1974. 15b, × 10. ☐ C. Detail of rings in early adult part, SMNH X 1218, × 75. ☐ D. Longitudinal section of almost complete specimen, SMNH X 1198, × 15. ☐ E. Longitudinal section of young individual. Note the thin first septum, SMNH X 1211, × 100. C, D, E. "Östergarn", unnumbered SMNH sample.

of one size. Cyclic pattern most distinctive in late proximal part and in adult part of conch. Rhythmic character occasionally difficult to see in early proximal part of many specimens. Ring cycles with 3–6 primary and secondary rings, number of rings per cycle generally increasing towards distal end, as does size and spacing of primary rings. Spacing or primary rings in early adult part 1.2–1.5 mm, 2.0–2.5 mm apart most distally. Secondary rings in primary interspaces regularly arranged. Each cycle generally with a wider secondary interspace between primary ring and secondary ring of the following cycle than the interspaces between secondary rings. Difference in width of interspace at distal end of adult specimens hardly noticeable. Secondary rings increasing gradually in size towards next primary ring, particularly clear in early and middle adult part. Sizes of secondary rings in final two cycles in large specimens equal. Rings symmetrical or slightly asymmetrical, the latter type found particularly in distal part of conch where distal slopes of primary rings may pass more or less directly into the following interspace. Secondary rings always symmetrical and generally sharply defined. Axial traces of primary rings opisthocline and prosocyrt, becoming more strongly opisthocline towards distal end. Secondary rings mostly orthocline with straight axial traces. Rings in profile bi-convex with rounded crests. Secondary rings slightly triangular occasionally. Proximal slopes always smooth, distal slopes with annulets and lirae. Primary rings high, distally reaching heights of 0.25–0.30 mm, height: basal width 1: 1.5–1.6.

Annulets developed in secondary interspaces and on distal slopes of rings, 1 or 2, seldom 3, in distal interspaces of each cycle, 5–7 rings normally in the wide proximal interspace of each cycle. Annulets regularly spaced. Annulets nearest crest of rings frequently somewhat thicker than the others. Proximal side of this annulet strongly concave producing a marked crestal furrow. Most of annulets prosocline, comparatively low and thin.

Secondary interspaces in juvenile and early adult part concave gradually becoming flatter towards distal end as the rings become more widely separated. Wide proximal interspace in each cycle always flat.

Comparatively weakly developed lirae occurring between annulets, density 9–10 per 0.1 mm. Proximal septal region: septa numerous, total number 10–15. Septa with straight or slightly concave free parts perpendicular to long axis of conch, spacing of free part 0.20–0.25 mm. Four or five most distal septa with thicker free parts and considerably thicker mural parts, the latter forming accretion zone. These septa occasionally forming true endocones. Distal septa often asymmetrical with concave and narrow free parts and mural parts of variable lengths. Last septum in most fully developed specimens conspicuously thick, generally developed at an outer conch diameter of 0.40–0.50 mm, or occasionally up to 0.65 mm.

Living chamber slightly conical constituting about 70–80% of the total length of the conch. Conical shape most conspicuous at the proximal end, which may have a narrow tip produced by the constriction of the last septum. Internal wall surface of first half of living chamber rather smooth, distal half more irregular. Annular concavities of primary rings well filled, annular shelves narrow except for rings close to aperture where they are much wider. Concavities are rather rapidly filled during growth of conch.

Primary and secondary shells easily distinguished. No pseudopuncta. Thickness of primary shell 0.02–0.04 mm in proximal part, 0.05–0.06 distally.

Remarks. – The holotype, which was figured and briefly described by Zagora (1974), is the most fully preserved specimen of *Podolites paeninsulicola* so far encountered. Unfortunately, the outermost lamellae of the primary shell are worn away and the annulets are only faintly preserved. The lirae have been removed entirely. Wear of the outermost lamellae has sharpened the outline of the rings so that distal slopes are much steeper than normal. Nevertheless, Zagora's figured specimen in Pl. 2: 1 is selected as holotype because it shows the characteristic rhythmicity of the rings.

There is some variation in the width of the ring cycle and the size of the secondary rings, particularly in the juvenile part. In many specimens the rhythmic arrangement is difficult to observe in this part because the rings tend to be of one size. Internally some variation may occur in the development of septa, particularly in the formation of endocones.

Podolites paeninsulicola is closely related to both *P. peregrinus* and *P. ternatus.* It differs mainly from these two species by having much higher and better defined symmetrical rings. The larger number of rings per cycle in the juvenile and early adult parts of the conch distinguishes the species from *P. ternatus.* The more symmetrical and higher rings distinguish *P. paeninsulicola* from *P. peregrinus.* The marked gradual increase in size of the secondary rings is particularly significant. The internal wall surface is smoother in *P. paeninsulicola* than in the other two *Podolites* species.

Occurrence. – *Podolites paeninsulicola* is restricted to the Hemse Beds. It has so far been encountered only from the Östergarn area in unit *c* of the Hemse Beds. The major part of the material derives from slabs of mudstone and argillaceous limestone kept at the State Museum of Natural History in Stockholm, and these slabs are only marked "Östergarn, Gotland". The lithology of the slabs leaves no doubt that they derive from the Hemse Beds, unit *c.* Some questionable specimens come from unit *b* at Gyle 1 but the material is too poorly preserved to allow safe specific determination. Thus, these specimens are designated *Podolites* cf. *paeninsulicola.*

Podolites ternatus n. sp.

Figs. 11G, 14, 53.

Derivation of name. – Latin *ternatus,* consisting of three, referring to the development commonly of three rings per cycle.

Holotype. – SMNH No. X 1185, Fig. 53A.

Type strata. – Klinteberg Beds, unit *a* (sample G 72-105 KL).

Type locality. – Gothemshammar 2, Gotland.

Material. – From the type locality 12 specimens, from other localities in the Halla Beds 110 specimens, from Klinteberg Beds 10 specimens and from the Hemse Beds 35 specimens.

Diagnosis. – Medium-sized *Podolites* proximal part expanding at 10–11°, distal part at 2–4°. Annulation cyclic mainly of three rings, occasionally with one four-ring cycle developed in early adult part. Living chamber with irregular internal wall surface.

Description. – Conch slender, proximal part expanding at 10–11°, distal part at 2–4°, straight except for slightly curved extreme juvenile part. Estimated full length of adult specimens 13–15 mm. Apical end with a well developed initial chamber, distinguished from rest of the conch by a slight constriction of conch. Initial chamber viewed along the sagittal plane symmetrical and triangular. Viewed perpendicularly to the sagittal plane, somewhat asymmetrical, having a flat side and convex side opposite. The initial chamber has a somewhat elongate apex, the tip of which is always broken off. Distal part of chamber with a characteristic asymmetrical ring with a steep distal slope, slightly oblique to long axis of conch. Length of initial chamber 0.15–0.18 mm, its maximum outer conch diameter ca. 0.08–0.10 mm. Aperture of conch perpendicular to long axis, outer distal diameter in adult specimens 1.20–1.25 mm.

Conch ornamented with rings of various sizes and annulets. Rings mostly perpendicular to long axis of conch except for immediately behind the initial chamber where the first 4 or 5 rings are distinctly oblique. Obliquity of these rings decreases gradually in a distal direction as does their spacing and asymmetry. Succeeding juvenile part starting with rings of equal size and spacing gradually passing to a ring pattern where rings alternate with one annulet in each interspace. Further distally rings increase gradually in size and spacing towards the first primary ring, developed at an outer conch diameter of 0.22–0.32 mm. Rings rather symmetrical. Remainder of conch showing a rhythmic development of rings in cycles generally of three, occasionally of four, rings. One four-ring cycle generally occurs at the very early adult part of conch after four or five cycles of three rings. In mature specimens groups of only two rings sometimes occur at the very distal end, from 0.70–0.80 mm apart in the early cycles to 1.35–1.55 mm apart in those most distal. Secondary rings occupying primary interspaces regularly spaced and somewhat distal in each cycle. Forming a wider secondary interspace between the primary ring and first secondary ring of the next cycle. Size of rings increasing in a distal direction within each cycle.

Rings of juvenile part asymmetrical with opisthocline or orthocline axial traces and rather steep distal slopes. Adult rings symmetrical or slightly asymmetrical, with orthocline or opisthocline attitude, the latter attitude being common in primary rings. Axial traces of primary rings opisthocline and opisthocyrt, in secondary rings orthocline and straight.

Rings convexo-concave in profile with rounded crests. Secondary rings occasionally triangular with narrow crests. Proximal slopes always smooth while distal slopes show annulets and lirae. Height-to-base: basal width of primary ring 1: 1.2–1.6.

Annulets distributed regularly in secondary interspaces as well as on distal slopes of the rings. One annulet developed immediately before the first primary ring in each interspace. Number of annulets in distal part of conch varying from 2 or 3 in the distal interspace of each cycle to 4 or 6 in the proximal wide interspace. Lower part of distal slopes of ring with one or two annulets. Annulets slightly prosocline and commonly symmetrical with a narrow, triangular cross-section. Height of rings moderate, seldom exceeding 0.01 mm.

Interspaces in juvenile part of conch clearly concave as in the distal portion of each cycle in adult part, proximal wide interspace of each cycle flat.

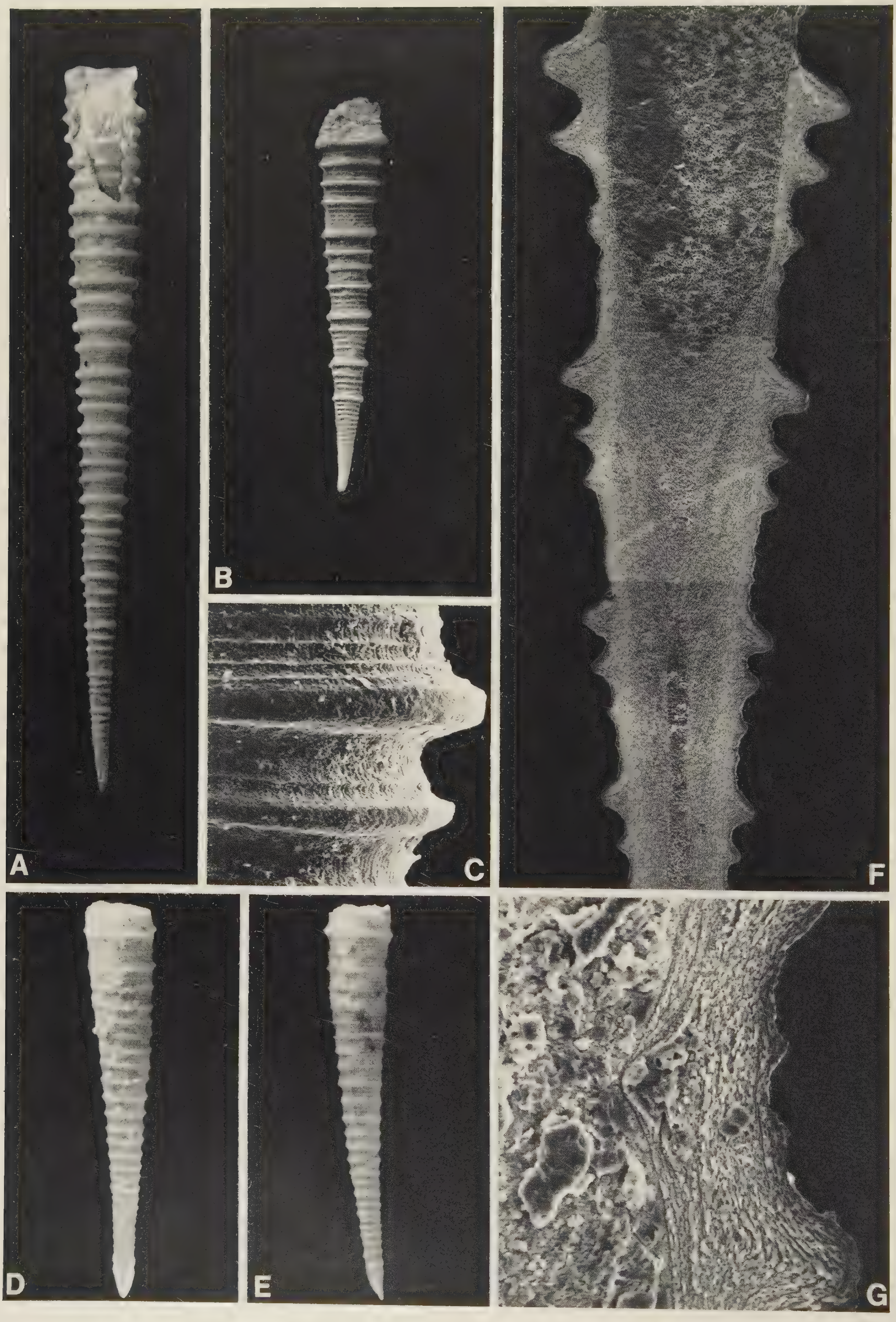
Lirae present along entire conch in tertiary interspaces of juvenile and adult parts, crossing the annulets. Density of lirae 7–9 per 0.1 mm.

Interior of initial chamber unknown. Proximal septal region with septa, in juvenile specimens thin, symmetrical and free, spaced ca. 0.2 mm apart. Mural parts of septa very thick because of rapid stacking of laminae in a distal direction. The rapid stacking makes the laminae oblique by up to 10° to the long axis of the conch. Adult specimens with free septa succeeded by septa forming symmetrical, densely packed endocones. Sides of cones dipping 30–40° to long axis. Endocones occur along a length of 0.5–0.7 mm, most distally at an outer conch diameter in fully mature specimens of 0.40–0.45 mm. Generally early endocones have rather pointed and narrow proximal ends while the most distal endocones show rounded ends.

Living chamber symmetrical with a conical proximal part and a subcylindrical distal part. Living chamber in mature specimens constitutes about 75–80 % of the total length of conch. Internal wall surface smooth at the proximal end, distinctly irregular along distal part because of poorly filled annular concavities. Proximal limbs of primary rings with a pronounced accumulation of laminae, producing well developed, occasionally opisthocline, annular shelves. Annular shelves far distal to crest of primary rings. Annular concavities rather asymmetrical. Secondary rings less filled, annular shelves very weakly developed, annular concavities, rings rather symmetrical, mainly reflecting the external shape of the rings.

Primary and secondary shells frequently easily distinguished. No pseudopuncta. Thickness of primary shell rather uniform, 0.01–0.02 mm proximally and 0.02–0.04 mm distally.

Remarks. – *Podolites ternatus* is recognized mainly by the ring pattern of three rings per cycle, the comparatively


A
B
C
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G

Table 31. Podolites ternatus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	TNCY	WLCY	NRLC	PA
SMNH X 1185 (holotype)	13.46	1.23	0.14	0.32		12	1.42	3	10°
SMNH X 1186	10.65	1.03	0.14			9	1.35	3	10°
SMNH X 1187	11.52	1.11	0.12	0.32		11	1.54	3	11°
SMNH X 1188	10.89	1.15	0.16	0.22		12	1.38	3	10°
SMNH X 1190	4.12	0.63	0.14	0.26	0.43	5	0.91	3	
SMNH X 1197	3.64	0.55	0.12	0.28	0.30	4	1.20	4	

dense arrangement of the cycles and the symmetrical rings. The general ring pattern is similar to that of *P. hedei* which occurs in the same beds on Gotland. The two species may be differentiated by differences in number of rings per cycle, in length of the cycles and in the shape of the rings. The extreme proximal parts of the two species may occasionally be difficult to distinguish. However, *P. ternatus* generally has a less curved juvenile part and a different ring pattern. The latter, though, is not always easy to observe because of problems in clearing the specimens properly.

The variation of the characters in *P. ternatus* is confined mainly to minor differences in the ring pattern, particularly in the proximal part where the first primary ring may be poorly developed, and in the length of the cycles. Material from the Hemse Beds commonly has a paired arrangement of the most distal rings.

Occurrence. – Podolites ternatus occurs from unit *c* of the Halla Beds up to unit *c* of the Hemse Beds. It is most abundant in the Halla Beds. It has not so far been observed outside Gotland.

Genus *Turmalites* Ljashenko 1969

Type species (by original designation). – *Turmalites podolicus* Ljashenko 1969; from the Lower Devonian of Podolia, USSR.

Species on Gotland. – Turmalites follingboensis, T. slitiensis.

Remarks. – The generic diagnosis by Ljashenko (1969a: 86) does not give many characters which distinguish this from other tentaculitid genera. Nor does the description of the type species. However, the accompanying illustrations (Ljashenko 1969a, Pl. 4: 1–6) give information sufficient to assign two Gotland species to this genus, i.e. *Turmalites follingboensis* and *T. slitiensis.* As no type material has been examined, an emended diagnosis of the genus must wait.

The genus has slender and narrow conchs, proximal part expanding at 5.5–10°, distal part at 3–4°. The conch is straight except for the proximal part which shows slight curvature. The conchs are medium in size, seldom exceeding 15 mm long. The initial chamber is conical without any significant constriction to separate it from the juvenile part. Distally the aperture is either perpendicular or slightly oblique to the long axis. The annulation is distinctly asymmetrical rings with marked hinge lines, arranged in cycles mostly of two, occasionally three, rings. This annulation is frequently slightly oblique. Rings are separated into primary and secondary rings, the former type being distal in each cycle. Annulets occur abundantly in each interspace and on the distal slopes of the rings. The proximal part of the conch is divided internally into camerae by free septa which have strongly irregular and asymmetrical free parts. Primary and secondary shells are well differentiated and pseudopuncta are present. The four *Turmalites* species described by Ljashenko (1969a) derive from the Lower Devonian of Podolia.

Fig. 53. Podolites ternatus n. sp. B Gothemshammar 1, G 72-104a. C, D, E, F. Gothemshammar 1, MS 895. G. Gothemshammar 1, MS 669. ☐ A. Holotype, SMNH X 1185, × 10; Gothemshammar 2, G 72-105 KL. ☐ B. Young individual, SMNH X 1167, × 15. ☐ C. Detail of primary ring and preceding secondary ring, SMNH X 1191, × 60. ☐ D, E. Early proximal part with preserved initial chamber in lateral, perpendicularly opposed, views, SMNH X 1189, × 50. ☐ F. Longitudinal section of septal region, SMNH X 1190, × 75. ☐ G. Longitudinal section of conch wall in early adult part showing foreign bodies included within the conch wall, SMNH X 1197, × 450.

Turmalites follingboensis n. sp.

Fig. 54.

Derivation of name. – Latin *Follingboensis,* inhabitant of the Follingbo area, in which the type locality is situated.

Holotype. – SMNH No. X 1061, Fig. 54A.

Type strata. – Slite Beds, *Slite Marl* (sample G 74-74 KL).

Type locality. – Follingbo 7, Gotland.

Material. – From the type locality 13 specimens, from additional localities in the Slite Beds more than 140 specimens and from the Högklint Beds more than 20 specimens.

Diagnosis. – *Turmalites* of medium size, narrow, proximal part expanding at 5.5–10°, distal part at 3–4°. Distal part straight, proximal part commonly slightly curved. Annulation commonly slightly oblique to long axis, rhythmical with rings in pairs gradually increasing in size and spacing distally. Rings clearly convexo-concave with

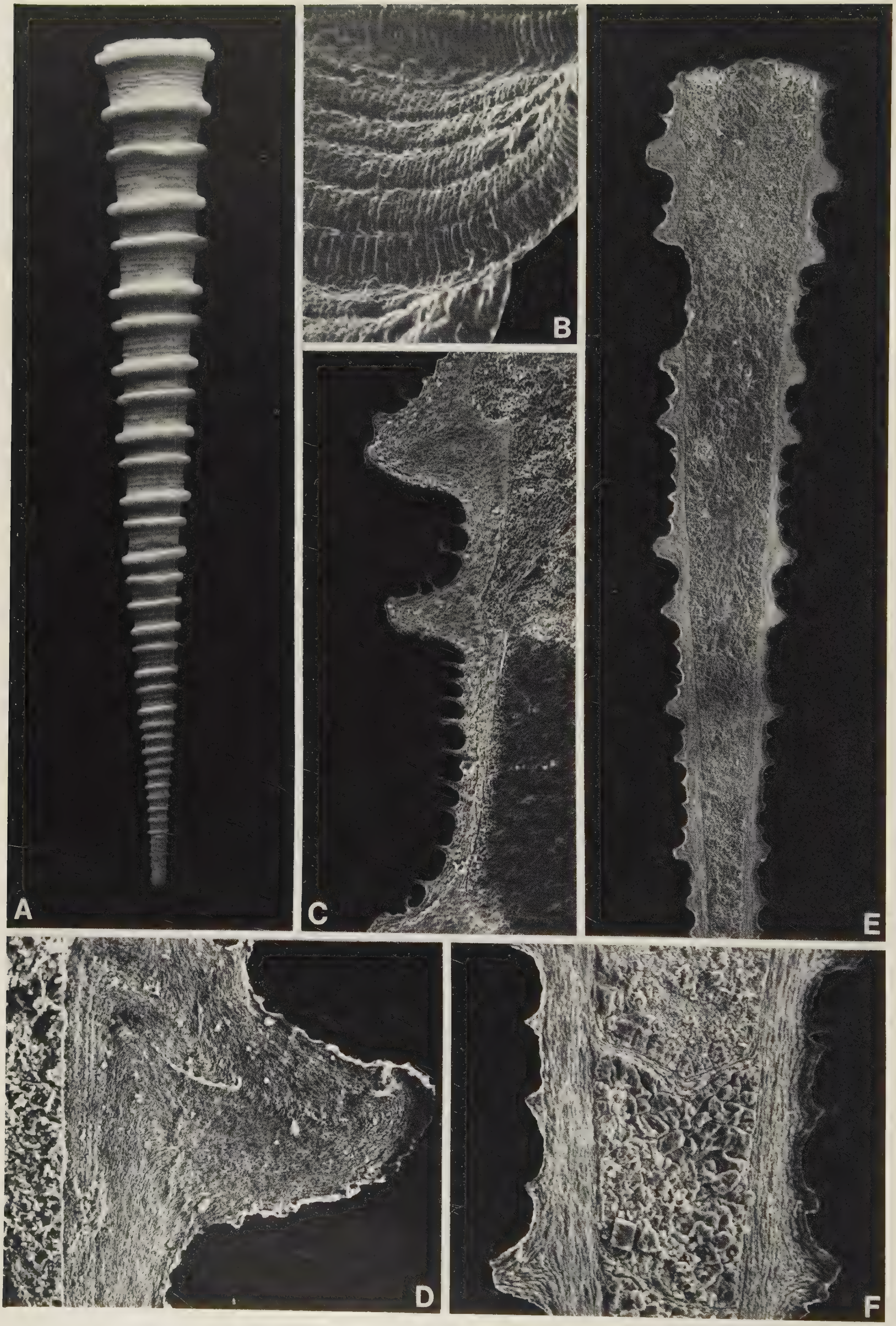
A
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Table 32. Turmalites follingboensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1061 (holotype)	10.65	1.25	0.20		10°
SMNH X 1062	9.80	1.13	0.13		8°
SMNH X 1063	6.12	0.90	0.10	0.28	7°
SMNH X 1073	10.77	1.00	0.10	0.40	6°
SMNH X 1074	6.50	0.63	0.10	0.28	5.5°
SMNH X 1075	7.05	0.65	0.15	0.29	6°
SMNH X 1076	9.50	1.03	0.28	0.40	8°

opisthocline axial traces. Proximal part divided internally by septa slanting in various directions, irregularly spaced and thin. Living chamber conical with irregular internal wall surface. Conch wall with faint pseudopuncta.

Description. – Narrow conch with a proximal growth angle of 5.5–10° and distal part expanding at 3–4°. Conch straight except for proximal part which frequently shows slight curvature. Estimated length of conch in mature specimens 11–13 mm. Initial chamber conical passing directly into juvenile part without any noticeable constriction of conch, outer conch diameter in this region ca. 0.05 mm. Aperture perpendicular or slightly oblique to long axis of conch. Outer distal diameter normally 1.00–1.25 mm.

Whole conch annulated by rings, distally mostly in pairs, proximally in groups of 2 or 3 rings. Most proximal rings not, or only weakly, arranged in pairs. Size of rings and their spacing increasing gradually in a distal direction. Density of rings 8–10 per mm proximally, 2–4 per mm distally. Ring pairs of one proximal secondary ring followed by a primary ring. Primary rings asymmetrical with opisthocline and prosocyrt axial traces. Profile of rings distinctly convexo-concave with a marked hinge line forming the crestal line of rings. Height of the most distal primary rings 0.17–0.20 mm, height: basal width 1: 1.5–1.75. Secondary rings also opisthocline occasionally with almost orthocline axial traces, prosocyrt only at the outermost part of rings, profile convexo-concave or almost angular with crests sharp.

Interspaces between rings covered by regularly spaced annulets. Distal slopes of distal rings normally with 1 or 2 annulets. One of these rings always has a fixed position close to the base of the ring. Number of annulets 8–10 in the wide interspaces and 3–4 in the narrow interspaces distally. Annulets distinctly prosocline in attitude, straight or prosocyrt in section. Outermost part of rings occasionally curved strongly inwards. Rings thin, less than 0.001 mm at the base and rising 0.05–0.10 mm above surface of interspace. Wide interspaces flat or slightly concave, narrow interspaces always distinctly concave.

Fig. 54. Turmalites follingboensis n. sp. ☐ A. Holotype, SMNH X 1061, × 15; Follingbo 7, G 74-74 KL. ☐ B. Oblique apertural view of ring, SMNH X 1070, × 100; Haganäs 1, MS 489. ☐ C. Longitudinal section of distal conch wall, SMNH X 1069, × 100; Follingbo 3, MS 485. ☐ D. Longitudinal section of ring, SMNH X 1072, × 250; Kappelshamn 2, G 72-43 KL. ☐ E, F. Longitudinal sections of juvenile and early adult parts, × 75, and detail of septa, × 250, SMNH X 1065; Follingbo 1, MS 419.

Whole conch ornamented with well developed lirae, occurring between annulets in the secondary interspaces and on the distal slopes of the rings. Lirae crossing annulets, density 6–7 lirae per 0.1 mm.

Proximal septal region: the most distal septum occurring at an outer conch diameter of 0.4 mm. First septum at an outer diameter of 0.075 mm and ca. 0.25 mm behind the apex of the initial chamber. First septum very thin and consisting of only one lamina, possibly organic. Total number of septa unknown but exceeding 7. Septa well spaced occurring at irregular intervals 0.20–0.50 mm apart, free parts perpendicular or oblique to long axis of conch, straight or slightly concave, direction of free parts normally varying within a specimen. Septa thin, only 0.001 mm. Mural parts of septa asymmetrical but long, extending along conch wall for 1.5–1.6 mm, thickness the same as the free parts tapering only gradually.

Living chamber conical with a blunt proximal end. Internal wall surface smooth proximally, undulating rather distinct distally, particularly close to aperture where asymmetrical annular concavities appear. Annular shelves of these rings occasionally distinctly concave and opisthocline. Annular concavities of secondary rings more symmetrical, annular shelves prosocline.

Primary shell with pseudopuncta in proximal limbs of rings. Secondary shell often easily distinguished from primary shell, in the septal region by an organic layer but also at rings. Thickness of primary shell is 0.03–0.05 mm proximally, gradually increasing to 0.08–0.10 mm distally.

Remarks. – The ring pattern of *Turmalites follingboensis* may show some variation in development of the bi-annulate arrangement. It is occasionally diffuse in the distal part, while in the proximal part it frequently has rings increasing gradually in spacing in a distal direction. The degree of obliquity may show some variation and the most distal rings are commonly more or less perpendicular to the long axis. Internally, the direction of the free parts of the septa is variable. This character is in common with the type species, cf. Ljashenko (1969a, Pl. 4: 1–6).

The bi-annulate ring pattern resembles that in species of *Lonchidium* d'Eichwald but never attains the strong cyclicity of the annulation in the latter. The shape of the rings is different.

Occurrence. – *Turmalites follingboensis* appears first in the Högklint Beds, unit *b*, where it occurs sparsely at only a few localities around Kappelshamn Bay in northwestern Gotland. It occurs in the southwestern facies of the Högklint Beds at Ansarve 1 and 3. The species ranges through the Slite Beds up to its last occurrence in the Ryssnäs Limestone. It is very abundant in the Slite Marl.

Turmalites slitiensis n. sp.

Figs. 12B, 55.

Derivation of name. – Latin *slitiensis,* from Slite, referring to the Slite Beds in which lies the type locality.

Holotype. – SMNH No. X 1077, Fig. 55A.

Type strata. – Slite Beds, Slite Marl (sample G 72-39 KL).

Type locality. – Follingbo 5, Gotland.

Material. – From the type locality 6 specimens, from additional localities in the Slite Beds more than 250 specimens.

Diagnosis. – Medium sized slender *Turmalites* with a proximal growth angle of 6–9°, distal part expanding at 1–3° or becoming subcylindrical. Initial chamber slightly drop-like, bilaterally symmetrical. Annulation cyclic with 3 or 4 rings per cycle proximally, 2 or 3 per cycle distally. Annulation slightly oblique. Rings with convexo-concave profile. Distal slopes of rings without annulets. Septa thin proximally, thick distally. Camerae highly constricted. Internal wall surface irregular. Pseudopuncta rare.

Description. – Conch slender, proximal part expanding at 6–9°, distal part at 1–3° or becoming subcylindrical. Distal part of conch straight, proximal part generaly showing slight curvature, length of adult specimens estimated at 16–17 mm. Initial chamber slightly drop-shaped with a pointed apex, clearly bilaterally symmetrical, constricted at juvenile part of the conch by a very faint annular depression. Outer conch diameter at this point 0.08 mm. Length of initial chamber ca. 0.15 mm.

Aperture slightly oblique to long axis of conch. Distal outer conch diameter in fully mature specimens 1.20–1.35 mm.

Whole conch ornamented with slightly oblique rings and annulets. The former arranged in a cyclic pattern. Rings of equal size in extreme proximal part but increasing gradually in a distal direction, density of rings 14–20 per mm. First primary ring developed at an outer conch diameter of 0.20 mm. Cycles of 3–4 rings. Rings generally arranged in pairs at the distal end. Cyclic pattern most distinct in juvenile and early adult parts of conch. Cycles extended towards the distal end so that rings are wide apart. Spacing of cycles increasing from 0.60–0.70 mm in juvenile part to ca. 2.0 mm in adult part. Primary rings increasing gradually in size towards distal end. Secondary rings occurring in primary interspaces and normally distal in each cycle, producing a wider secondary interspace between the primary ring and the succeeding secondary ring. Distally differences in spacing of rings are less obvious. Secondary rings increasing gradually in size within each cycle, most obvious in juvenile part of conch.

Table 33. Turmalites slitiensis n. sp. (dimensions in mm)

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1077 (holotype)	10.49	0.75	0.18		6°
SMNH X 1078	8.55		0.15		6°
SMNH X 1079	14.81	1.35	0.25		8°
SMNH X 1081	10.08	0.93	0.20		7°
SMNH X 1082	12.91	0.80	0.10		8°
SMNH X 1094	8.07	0.95	0.16	0.28	9°

Rings asymmetrical, opisthocline or occasionally orthocline, with straight to opisthocyrt axial traces. Shape of rings convexo-concave with rounded, or sometimes flattened, crests, hinge line rather sharp occasionally forming the crestal line of the ring. Height of primary ring 0.04–0.07 mm proximally, 0.12–0.15 mm distally. Height: basal width 1: 1.6–2.1.

Secondary interspaces in juvenile part concave except for the wider proximal interspace of each cycle which is comparatively flat. Interspaces gradually flatter as they become wider towards the distal end.

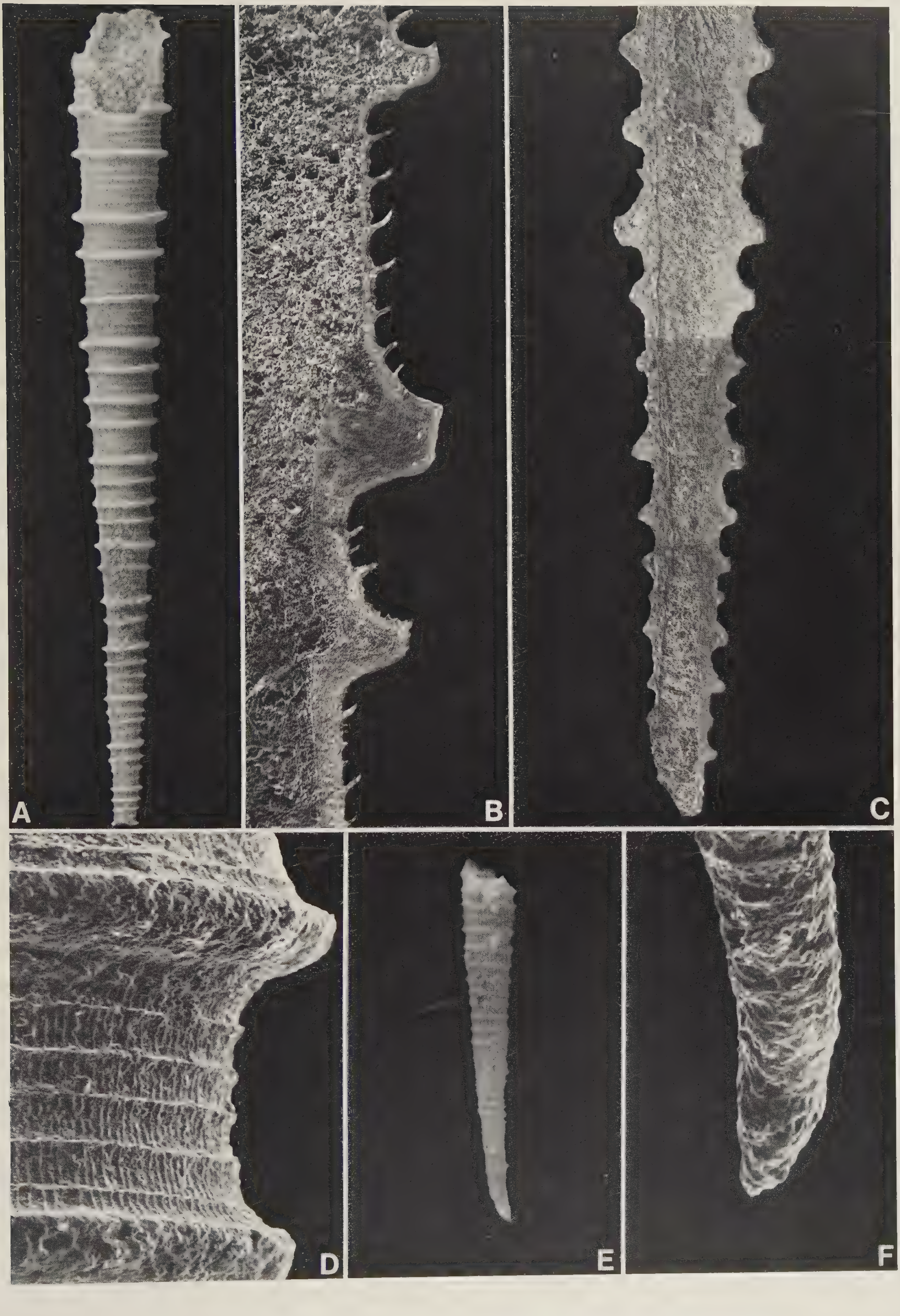
Interspaces with distinct annulets, one proximally, sometimes two in the distal secondary interspaces, and 3 or 4 in the wide, proximal interspace of each cycle. Distal part of conch with 5–7 annulets between rings. Annulets regularly spaced, attitude slightly prosocline showing a prosocyrt curvature in section. Height of annulets 0.05–0.07 mm while the basal width is ca. 0.01 mm.

Whole conch ornamented with distinct lirae, occupying tertiary interspaces, crossing annulets, and extending onto the distal slopes of rings up to hinge line. Density of lirae 8–10 per 0.1 mm. It has not been possible to examine the interior of the initial chamber. Proximal septal region with regularly spaced septa, 0.15–0.17 mm apart. Minimum number 8. Last septum forms at a conch diameter of ca. 0.30 mm. Free parts of septa straight or slightly concave and perpendicular to long axis. Septa generally thin, ca. 0.005 mm, but last 3–5 are generally thicker, up to 0.015 mm. Mural parts subparallel to conch wall and rather persisting. Mural parts of the most distal septa form an accretion zone of length 1.10–1.50 mm.

Living chamber conical initially, proximal end with blunt tip reflecting the constriction of the last septum. Distal part of living chamber approaching subcylindrical in shape. Internal wall surface irregular along the whole chamber, reflecting various stages in accumulation of lamellae in the annular concavities. Concavities displaced far distally in relation to the crest of the rings. Accumulation of lamellae particularly great on the proximal limbs of the primary rings, and distinct, opisthocline annular shelves are formed. Secondary rings are also filled rapidly, but in these rings shallower annular concavities form which are proximal to the crest.

Primary and secondary shells easy to distinguish. Few faint pseudopuncta observed in primary rings. Thickness

Fig. 55. Turmalites slitiensis n. sp. ☐ A. Holotype, SMNH X 1077, × 15; Follingbo 5, G 72-39 KL. ☐ B, C. Longitudinal sections of distal conch wall, × 100, and juvenile part, × 60, SMNH X 1094; Follingbo 7, G 74-74 KL. ☐ D. Detail of distal interspace and rings, SMNH X 1090, × 100; Haganäs 1, MS 489. ☐ E. Juvenile part with preserved initial chamber, SMNH X 1092, × 40; Allekvia 1, Got 74-35 SB. ☐ F. Detail of initial chamber and early juvenile part, SMNH X 1095, × 200; sample as for E.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of primary wall fairly uniform along entire conch, between 0.03–0.05 mm.

Remarks. – *Turmalites slitiensis* is recognized primarily by the rhythmic, slightly oblique, proximal ring pattern which mostly has three rings per cycle and by the extended, less rhythmic, distal cycles. The clearly convexo-concave profile of the rings and the lack of annulets on their distal slopes are significant external characters. Variations in the rhythmic development may occur, particularly in the distal part. The number of rings per cycle may vary, occasionally being 5 or 6.

Turmalites slitiensis shows similarities in the distal part of the conch to *Turmalites follingboensis,* particularly if the bi-annulate ring pattern is pronounced. Generally, the rings of *T. follingboensis* are more strongly oblique than the rings of *Turmalites slitiensis.* The distal part of *T. slitiensis* may resemble that of *Dicricoconus acutalis.* However, the latter species has denser rings and in the primary interspaces has secondary rings, not annulets as in *Turmalites slitiensis.*

Occurrence. – *Turmalites slitiensis* is a common species in the Slite Beds unit *g* and in the Slite Marl. One questonable occurrence is from unit *d* of the Slite Beds (Stora Myre 1). However, the state of preservation does not permit safe determination. Some specimens found at Vallstena 1 indicate that the species extends into the *Pentamerus gotlandicus* Beds. *Turmalites slitiensis* has not been found outside Gotland.

Genus *Volynites* Ljashenko 1957

Type species (by original designation). – *Volynites russiensis* Ljashenko 1957; from the Borshchov Stage, Lower Devonian of Podolia.

Species on Gotland. – *Volynites muldiensis* n. sp., *V. scalpratus* n. sp.

Stratigraphical and geographical distribution. – The type species derives from the lowermost Lochkovian of Podolia. Other *Volynites* species described are from the Lower Devonian of Massif Armoricain, France, and northern Poland. On Gotland, the genus is represented only in the uppermost Wenlockian.

Remarks. – A new diagnosis is needed for *Volynites* Ljashenko because the original (Ljashenko 1957c: 96) is too general and does not mention important characters which distinguish the genus from other Volynitidae, e.g. *Podolites* Ljashenko. The type material needs to be re-examined first because the published illustrations Ljashenko (1957c, Pl. 3: 1–2) are insufficient for this purpose.

From the Gotland species referable to this genus, *Volynites muldiensis* n. sp. and *V. scalpratus* n. sp., it appears that the genus is closely related to *Podolites* Ljashenko, but may be distinguished from it by having less rounded rings, and annulets in the proximal and early distal parts of the conch are poorly developed or even lacking.

Table 34. Volynites muldiensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	PA
SMNH X 1255 (holotype)	9.40	0.83	0.20	0.69		5.5°
SMNH X 1230	9.50	0.83	0.18	0.71	0.32	5°
SMNH X 1231	7.68	0.67	0.12	0.51	0.27	6°
SMNH X 1232	10.10	0.75	0.14	0.57	0.30	5°
SMNH X 1233	7.84	0.59	0.14	0.43	0.26	5.5°
SMNH X 1234	9.90	0.71	0.14	0.51	0.34	5°
SMNH X 1242	11.50	0.99	0.16	0.69		6°
SMNH X 1243	10.30	0.79	0.12	0.57		6°
SMNH X 1244	6.41	0.65	0.16	0.49	0.45	6°

The two *Volynites* species occur in the Mulde Beds of Gotland (uppermost Wenlockian). This is the earliest record of the genus.

Volynites muldiensis n. sp.

Figs. 7D–F, 9A–B, 18A–B, 19A, D, 20, 21, 23A, 56.

Derivation of name. – Latin *Muldiensis,* from the Mulde area, which includes the type locality.

Synonymy. – ☐ *Tentaculites* sp. – Fisher, 1962: W110, Fig. 55: 8 (*partim*). ☐ *Tentaculites* (s.l.) n. sp. B – Zagora, 1974: 1225, Pl. 3: 1–8.

Holotype. – SMNH No. X 1255, Fig. 56A.

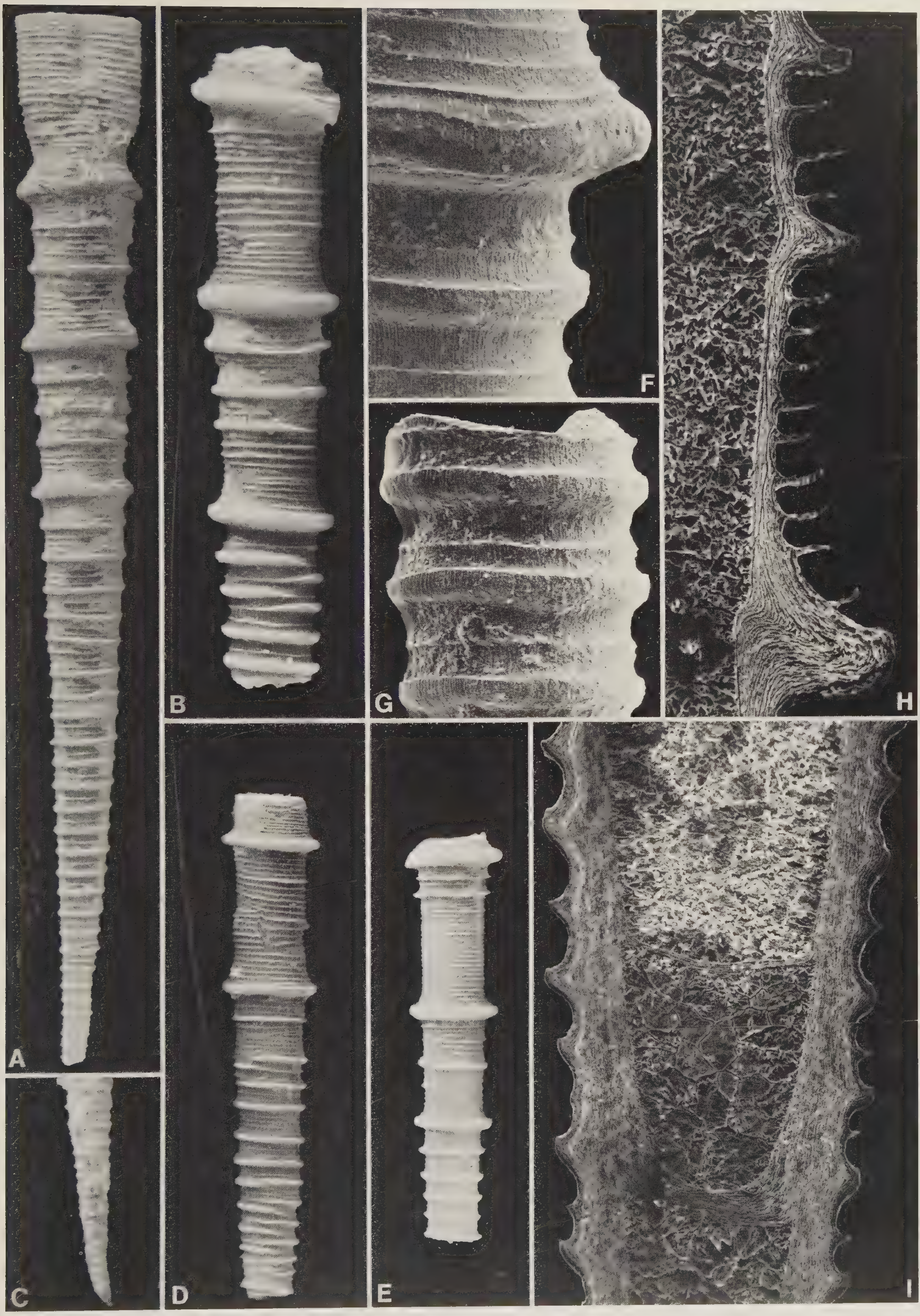
Type strata. – Mulde Beds (sample MS 608).

Type locality. – Mulde Tegelbruk 1, Gotland.

Material. – From the type locality over 4.600 specimens, from additional localities in the Mulde Beds 315 specimens, and 3 specimens from the Halla Beds.

Diagnosis. – Medium sized, slender, *Volynites,* proximal part expanding at 4–6°, distal part at 1–3°, straight except occasionally with slight proximal curvature. Initial chamber steeply conical, at a slight angle to proximal part. Annulation of two types; proximal pattern of slightly oblique secondary rings separated by few annulets. Rings occasionally varying in thickness around their circumference, distal pattern of widely spaced

Fig. 56. Volynites muldiensis n. sp. A, B, F, G. Mulde Tegelbruk 1, MS 608. C. Mölner 1, G 74-40 KL. D, E. Mulde Tegelbruk 1, MS 10/1961: coll. H. Mulde Tegelbruk 1, MS 798; I. Mulde Tegelbruk 1, unnumbered SMNH sample. ☐ A. Holotype, SMNH X 1255, × 20. ☐ B. Specimen showing irregular secondary rings proximal to the first primary ring, SMNH X 1683, × 25. ☐ C. Juvenile part with initial chamber, SMNH X 1258, × 40. ☐ D. Specimen showing late juvenile and early adult parts with repairs to the conch wall, SMNH X 1249, × 15. ☐ E. Early adult part of conch, SMNH X 1254, × 15. ☐ F. Detail of distal rings, SMNH X 1257, × 75. ☐ G. Detail of secondary rings immediately proximal to the first primary ring, SMNH X 1256, × 75. ☐ H. Longitudinal section of distal conch wall, SMNH X 1219, × 175. ☐ I. Longitudinal section of septal region, SMNH Mo. 41147, × 250.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primary rings separated by interspaces with variable number of secondary rings and having annulets. Rings asymmetrical, convexo-concave. Lirae well developed, proximally occasionally on crests of rings. Proximal part divided internally by numerous septa, those most distal slightly thickened and forming an accretion zone or endoconic. Living chamber conical with pointed proximal end and irregular internal wall surface. Conch wall without pseudopuncta.

Description. – Conch slender, proximal part expanding at 4–6°, distal part at 1–3°, change in growth angle gradual. Normally straight but occasionally with slight proximal curvature. Adult length 9–11 mm, occasionally 12 mm.

Initial chamber distinctly conical, deviating slightly in direction from adjacent proximal part, bilaterally symmetrical, with a slightly flattened side towards the concave curvature and an opposite, convex side, apex pointed. Distal half of chamber ornamented with a pair of minute rings. Length of chamber ca. 0.15 mm, distal diameter ca. 0.07 mm. Interior of initial chamber unknown.

Aperture perpendicular to long axis. Outer distal diameter mostly 0.95–1.00 mm, seldom exceeding 1.10 mm.

Ornament of rings and annulets in two basic patterns. Juvenile and early adult parts, i.e. almost 2/3 of total length, with rings of gradually greater size and spacing, rings alternating with annulets, both often oblique to long axis. Interspaces between very early rings concave, smooth, at conch diameter ca. 0.15 mm each interspace with one annulet commonly in the proximal half, more distally each interspace with two or three annulets of equal size and spacing. Density of rings changing gradually from 5–7 per mm proximally to 3–4 per mm by first primary ring. Rings low, clearly asymmetrical, with orthocline or weakly prosocline axial traces, profile convexo-concave, crests rounded, hinge lines sharp. Height: basal width of ring 1: 1.5–2.0. Thickness of 4 or 5 rings immediately proximal to first primary ring varying occasionally along the circumference, thus resembling annulet (Fig. 56B; Zagora 1974, Pl. 3: 1–2).

Annulets small, 0.02–0.03 mm high, triangular in section, outer margins extended into thin prosocline flange.

Distal ring pattern of widely spaced primary rings separated by secondary rings and annulets. Primary rings normally 3 or 4 but occasionally 5, 1.50–2.70 mm apart, rather irregular but interval seldom increasing. First primary ring normally at outer conch diameter of 0.65–0.80 mm, size increasing gradually distally. Primary rings asymmetrical, orthocline, with axial traces strongly opisthocline and slightly prosocyrt, but often diffuse in outer part because of hemispherical laminae, profile convexo-concave, hinge lines relatively marked. Height of distal rings 0.13–0.15 mm, height: basal width 1: 1.0–1.5.

Distal secondary rings similar in size and shape to those of juvenile and early distal parts; 3–5, generally regular in first or first two primary interspaces, and with gradual slight increase distally in each interspace, most distal primary interspaces with only one or two, variously positioned secondary rings. Secondary rings absent from some conchs.

Distal annulets well-developed, regularly spaced in secondary interspaces and on distal slopes of the primary rings, one or two normally between the secondary rings. Most distally, density 14–20 per mm. Annulets slightly prosocyrt, slender in section, height 0.03–0.05 mm, basal width 0.003–0.005 mm.

Interspaces mostly concave, as is particularly evident in tertiary interspaces, secondary interspaces also slightly concave.

Lirae distinct over whole conch, occupying tertiary interspaces and crossing annulets, in some conchs lirae also on crests but not on proximal slopes of rings in juvenile part, never on crests of primary rings. Distal density of lirae 8–10 per 0.1 mm.

Proximal septal region; septa numerous, often more than 10, well spaced and free except distally occasionally endoconic. Free parts slightly concave or straight and commonly somewhat oblique to long axis. Proximal septa thin, but most distal 4–6 strongly thickened. Mural parts particularly thick and generally forming an accretion zone 1.5–3.0 mm long, mural parts comparatively short and decreasing rapidly in thickness so that camerae are pronouncedly conical. Proximal camerae subcylindrical. Most distal septum in adult specimens at conch diameter of 0.25–0.35 mm, in some large specimens at 0.40–0.45 mm; septum generally with narrow free part and rapidly tapering mural part.

Living chamber proximally fairly pointed because of shape of last septum, distally symmetrical and conical with irregular internal wall surface. Annular shelves distinct, generally orthocline or slightly opisthocline.

No pseudopuncta. Primary shell distinguished easily from secondary shell by distinct inner organic layer. Thickness of primary shell 0.005–0.01 mm proximally, 0.02–0.03 mm distally.

Remarks. – The characteristic ring pattern of *Volynites muldiensis* distinguishes it from all other species on Gotland. Some variation occurs in the obliquity of the proximal rings and, particularly, in the distal ring pattern in the spacing of the primary rings and the number of secondary rings per interspace. Internally, the position of the last septum varies among populations.

Occurrence. – *Volynites muldiensis* has only been identified certainly from the Mulde Beds, where it forms the dominant species in the upper part. Some poorly preserved specimens, herein designated as *Volynites* cf. *muldiensis*, have been found at Gandarve 1 in the Halla Beds. The species is still unknown outside Gotland.

Volynites scalpratus n. sp.

Figs. 8E, 57.

Synonymy. – ☐ *Tentaculites* sp. – Fisher 1962: W110, Fig. 55: 8 (partim). ☐ *Tentaculites* (s.l.) *wenlockianus* Vine – Zagora 1974: 1226, Pl. 1: 5–6 4: 10–12.

Derivation of name. – Latin *scalpratus*, having a sharp edge, referring to the rings.

Holotype. – SMNH No. X 1270, Fig. 57A.

Type strata. – Mulde Beds (sample G 77-5 KL).

Type locality. – Mulde Tegelbruk 1, Gotland.

Material. – From the type locality, 108 specimens.

Diagnosis. – Medium-sized, slender *Volynites* with curved proximal part and straight adult part. Proximal growth angle 6.5–8°. Annulation of cycles of 4–7 rings, each cycle with one distinct primary ring and several secondary rings. Juvenile part with regularly spaced secondary rings. Rings high, well defined, crests sharp. Annulets absent, or few in the secondary interspaced and on the distal slopes of the distal rings. Interspaces concave. Lirae distinct. Living chamber with irregular internal wall surface, annular shelves distinct. Conch wall with pseudopuncta, distinct in proximal limbs of rings, less distinct in distal limbs.

Description. – Slender, proximal part expanding at 6.5–8°, distal part at 2–3°, change in growth angle gradual. Very early proximal part commonly subcylindrical, clearly curved up to first primary ring with maximum deflection of 0.20–0.25 mm from sagittal plane through distal living chamber. Medium-sized, estimated full length 12–13 mm, but no initial chamber found. Minimum proximal diamter 0.11 mm, outer distal diameter 1.30–1.50 mm in adults, aperture perpendicular to long axis.

Ornament of distinct rings and annulets perpendicular to long axis. Curved proximal part with regularly spaced secondary rings along most of length up to first primary ring; the latter at outer conch diameter of 0.45–0.55 mm and more than 3 mm from apex.

Juvenile rings of gradually greater size and spacing distally, in extreme subcylindrical part dense and much smaller than later rings, density decreasing from 9–10 per mm proximally to 6–7 per mm immediately before first primary ring. Secondary rings asymmetrical, orthocline, profile convexo-concave, crests rounded, hinge lines very sharp and often extended into strongly prosocline, short flange. Height: basal width ca. 1: 1.

Distal rings in distinct cycles; number of cycles in fully adult specimens 5 or 6, rings per cycle 4–7 proximally and 3 or 4 distally, each cycle with one distinct primary ring and several secondary rings either of one size or gradually increasing in size distally. Primary rings 0.80–2.00 mm apart, spacing normally increasing gradually distally. Spacing of first two primary ring frequently wider than thereafter and with more rings, often 5 or 6, than later cycles.

Primary rings asymmetrical, with orthocline, straight, slightly opisthocyrt or prosocyrt axial traces. Profile convexo-concave, crests rounded, hinge line sharp, proximal slopes generally much steeper than distal slopes. Primary rings high, most distally 0.15–0.20 mm above adjacent interspaces. Height: basal width 1: 0.7–0.8.

Distal secondary rings regularly spaced in primary interspaces, normally with somewhat wider spacing between the primary ring and the succeeding secondary ring. Size gradually increasing distally but constant within cycles, attitude and shape of rings similar to those proximally.

Annulets almost absent from juvenile part, if present always occupying secondary interspaces immediately before first primary ring and only one per interspace. Annulets rare in distal part, earliest cycles commonly with only one annulet per secondary interspace, most distal cycles with 6 or 7 annulets in wide proximal interspace but only one or two in other interspaces. Annulets extending onto distal slopes of rings, 2 or 3 regularly spaced, opisthocyrt or, more rarely, prosocyrt. Height of annulets 0.03–0.05 mm. At distal end, annulets with wider bases and more triangular in cross-secion.

All secondary and tertiary interspaces concave, particularly distinctly so in juvenile part where slopes of rings continue directly into interspaces, the most distal secondary interspace commonly sloping inwards slightly.

Lirae very distinct along whole conch, occupying all tertiary interspaces and distal slopes of rings, always crossing annulets. In some specimens traces on crests of rings, always absent from proximal slopes. Density 6 per 0.1 mm proximally, 5–6 per 0.1 mm distally.

Proximal septal region with numerous, frequently 10–15, septa. Septa regularly spaced, perpendicular to long axis, free parts straight or slightly concave. Distal septa rather thick, commonly forming a distinct accretion zone up to 3–3.5 mm long and occasionally endoconic because of prominent thickening of mural parts. Mural parts of all septa long, 0.7–1.00 mm. Last septum at outer conch diameter of 0.50–0.55 mm.

Living chamber symmetrical, conical, with narrow proximal end. Internal wall surface smooth proximally, strongly irregular distally because of incomplete filling of annular concavities. Annular shelves very prominent, ortho- or opisthocline in primary rings, prosocline in secondary rings. Secondary interspaces sloping inwards slightly so diameter of living chamber somewhat less before than after a ring.

Pseudopuncta distinct in proximal limbs of rings, best developed in outermost lamellae, less distinct in distal limbs and parts of secondary interspaces. Primary shell distinguished easily from secondary shell, thickness 0.01–0.02 mm in juvenile part, 0.03–0.04 mm in distal part.

Remarks. – *Volynites scalpratus* is easily recognized because of the characteristic arrangement of rings and their sharp-edged crests. Furthermore, the absence of annulets from proximal secondary interspaces, the comparatively low number of annulets distally and the distinct lirae are significant features. Generally, the characters vary little; the position of the first primary ring and the spacing between it and the next primary ring may vary slightly.

Volynites scalpratus was identified as *T. wenlockianus* Vine by Zagora (1974, Pl. 1: 5–6, 4: 10–11). There is good reason to believe that reports of *T. wenlockianus* in the Mulde Beds, e.g., Chapman (1901: 157), van Hoepen

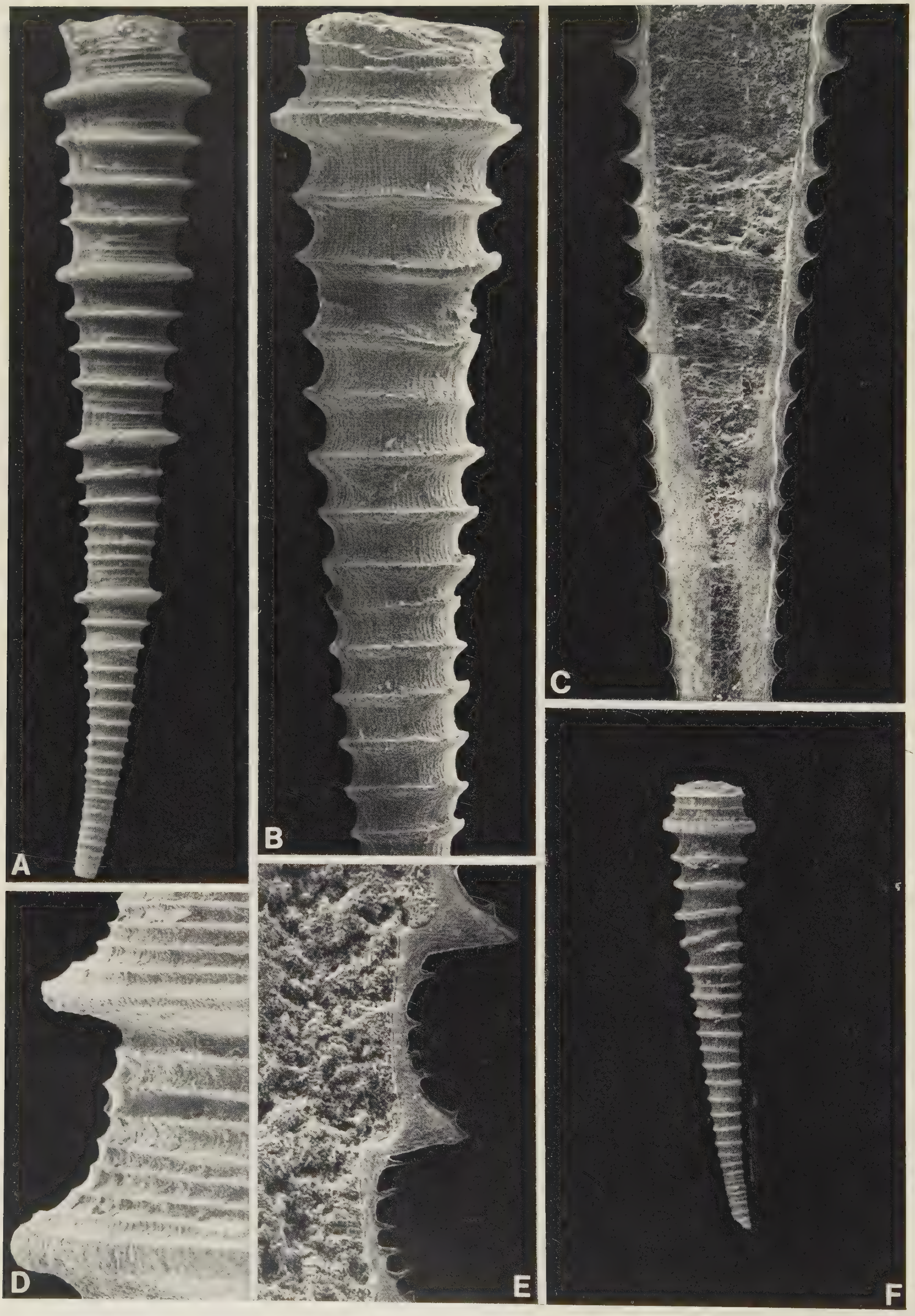
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Table 35. Volynites scalpratus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	WLCY	PA
SMNH X 1270 (holotype)	6.45	0.87	0.14		1.39	7.5°
SMNH X 1271	7.29	0.83	0.16		1.54	7°
SMNH X 1277	5.27	0.83	0.28		1.15	7°
SMNH X 1280	5.07	0.83	0.26		0.87	8°
SMNH X 1281	4.24	0.83	0.28		1.31	8°
SMNH X 1282	3.56	0.59	0.16	0.50	1.03	7.5°
SMNH X 1283	6.57	1.07	0.48		1.09	
SMNH X 1284	5.98	0.75	0.14	0.55	1.74	6.5°
SMNH X 1285	3.76	0.59	0.12	0.50	0.79	7°

(1910: 146), Hede (1927: 38), refer to *Volynites scalpratus*. There are some similarities to Vine's (1882) figured specimens, Pl. 15: 5–6, especially the general arrangement of the distal rings and the concave interspaces. However, Vine's figures have numerous annulets in the interspaces, a feature not found in *Volynites scalpratus*. Examination of Vine's type material reveals no more similarities of *T. wenlockianus* to *Volynites scalpratus*. Vine's material is unfortunately fragmented and is mainly distal parts. The rings are comparatively low and without the sharp crests to rings so characteristic of *Volynites scalpratus*.

Occurrence. – *Volynites scalpratus* has a very limited distribution both geographically and stratigraphically. It has only been found at the type locality in the Mulde Beds.

Family Rossiitidae Ljashenko 1969

Type genus. – *Rossiites* Ljashenko.

Genera. – *Dicricoconus* Fisher, *Omulites* Ljashenko, *Rossiites* Ljashenko, *Samarites* Ljashenko.

Stratigraphical and geographical distribution. – Representative of this cosmopolitan family occur in the lower and middle Devonian.

Remarks. – The original diagnosis by Ljashenko (1969c: 111) is sufficient to differentiate this from all other tentaculitid families. The most characteristic features are the well spaced primary rings separated by numerous secondary rings, and the smooth internal wall surface of the living chamber. Only one genus, *Dicricoconus* Fisher, is represented in Sweden.

Fig. 57. Volynites scalpratus n. sp. ☐ A. Holotype, SMNH X 1270, ×25; Mulde Tegelbruk 1, G 77-5 KL. ☐ B. Lateral view of late proximal part and first primary ring, SMNH X 1272, ×60; Mulde Tegelbruk 1, MS 765 D. ☐ C. Longitudinal section of septal region, SMNH X 1274, ×75; Mulde Tegelbruk 1, MS 608. ☐ D. Detail of rings, SMNH X 1273, ×75; sample as for B. ☐ E. Longitudinal section of distal conch wall, SMNH X 1275, ×100; sample as for C. ☐ F. Juvenile part, SMNH X 1276, ×25; Mulde Tegelbruk 1, MS 765C.

Genus *Dicricoconus* Fisher 1962

Synonymy. – ☐ *Tentaculites* von Schlotheim 1820 (*partim*) – Ljashenko 1954. ☐ *Heteroctenus* n. gen. – Ljashenko 1955. ☐ *Dicricoconus* n. gen. (nom. subst. pro *Heteroctenus* Ljashenko 1955, preocc.).

Type species (by original designation). – *Tentaculites mesodevonicus* Ljashenko 1954; from the Givetian of USSR.

Species on Gotland and in Scania. – *Dicricoconus acutalis* n. sp., *D. aemulus* n. sp., *D. clintianus* n. sp., *D. cracens* n. sp., *D. gutnicus* n. sp., *D. svarvariensis* n. sp., *D. tenuissimus* (Hede), *D. valliensis* n. sp.

Diagnosis (emended herein). – Straight, or with slight proximal curvature, small- to large-sized, 7–30 mm long, initial chamber conical, aperture perpendicular to long axis. Ornament of rings of different size, widely spaced, occurring singly or in pairs or threes. Interspaces flat or concave, with numerous regular, smaller rings. Proximal septal region with free, straight, regularly spaced septa. Internal wall of living chamber smooth. No pseudopuncta.

Stratigraphical and geographical distribution. – The type species, *Dicricoconus mesodevonicus* (Ljashenko 1954) occurs in the Middle Devonian of USSR. Other species of the genus occur in beds of Ludlovian-Frasnian age. The genus is cosmopolitan. On Gotland the genus is represented from the Slite to the Hemse Beds.

Remarks. – The characteristic features of *Dicricoconus* Fisher are the widely spaced primary rings occurring singly or in pairs or threes, and separated by interspaces with or without smaller secondary rings and abundant annulets, and the smooth internal wall surface of the living chamber. The absence of pseudopuncta is also typical. The rings adjacent to primary ring(-s) are often, gradually, larger; in several species this gives the interspaces a most distinctive concave shape. These features serve well to distinguish the genus from all other known tentaculitid genera. The pattern of paired rings frequently observed in *Dicricoconus* resembles that of *Lonchidium*, but internal structures are different. The latter genus has a distinctly irregular internal wall surface. The paired rings in *Dicricoconus* are much denser than in *Lonchidium*.

A number of species have been referred by Ljashenko (1959), and Lardeux (1969) to this genus. Lardeux's (1969) generic designation is uncertain because no sections of internal structures are figured.

Dicricoconus acutalis n. sp.

Fig. 58.

Derivation of name. – Latin *acutalis*, pointed, sharpened, referring to the sharpedged crests of the secondary rings and the annulets.

Holotype. – SMNH No. X 1126, Fig. 58A.

Type strata. – Slite Beds, *Slite Marl* (sample G 74-13 KL).

Type locality. – Gane 2, Gotland.

Material. – From the type locality 17 specimens, from other localities over 100 specimens.

Diagnosis. – Narrow, medium-sized, straight, occasionally with slight proximal curvature. Proximal part expanding at 4.5–5.5°, distal part at 2–4°. Annulation, proximally with regularly spaced primary rings separated by regular secondary rings, distally frequently with irregularly spaced primary rings. Primary rings distinctly convexo-concave, secondary rings angular or cuspidate with sharp crests. Annulets sparse. Lirae well-developed. Primary and secondary shells distinct.

Description. – Narrow, proximal part expanding at 4.5–5.5° and distal part at 2–4°, straight or occasionally with slight proximal curvature. Length in fully adult specimens estimated as 12–14 mm, no initial chamber found. Smallest outer proximal diameter 0.06 mm, outer distal diameter generally 0.85–0.90 mm, aperture perpendicular to long axis.

Annulation prominent, with rings and annulets perpendicular to long axis. Rings regular proximally but less regular distally; proximal part up to outer conch diameter of 0.20 mm with rings of one size and regularly spaced, further distally distinct primary rings occurring at regular intervals and generally 0.45–0.55 mm apart. Primary interspaces with 4 or 5 secondary rings either of one size or increasing gradually in size distally. Distal primary rings regularly or irregularly spaced, the latter type denser, interspaces with 3–6 secondary rings commonly of rather irregular size. Density of primary rings 2–3 per mm both proximally and distally.

All primary rings asymmetrical, slightly prosocline, axial traces slightly prosocyrt, profile convexo-concave, crests rounded. Height of distal rings 0.1 mm, height: basal width 1: 1.5–2. Secondary rings mostly symmetrical or slightly asymmetrical, prosocline, prominently angular to cuspidate with sharp crests. Height of secondary rings 0.03–0.06 mm. Size generally very variable, even within an interspace.

Annulets sparse in secondary interspaces. Distinction of annulets from small rings sometimes difficult, but in section easily distinguished.

Primary interspaces flat, secondary interspaces clearly concave.

Lirae distinct in tertiary interspaces, density 8–10 per 0.1 mm, crossing crests of annulets but never of rings.

Proximal septal region; septa very thin, variably spaced, 0.20–0.45 mm apart. Free parts perpendicular or oblique to long axis, straight or, particularly in the thinnest septa, frequently slightly undulating. Mural parts very long, stacking increasing considerably the total thickness of the wall. Total number of septa and position of last septum in fully grown specimens not determinable from material available.

Table 36. Dicricoconus acutalis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	PA
SMNH X 1126 (holotype)	8.36	0.83	0.22		5°
SMNH X 1128	2.85	0.36	0.08		5°
SMNH X 1129	7.44	0.61	0.18		5°
SMNH X 1130	8.59	0.67	0.14		4°
SMNH X 1135	3.88	0.50	0.16		5.5°
SGU Te 55	8.24	0.68	0.20	0.24	
SGU Te 56	5.80	0.52	0.06	0.18	5°
SGU Te 57	6.24	0.60	0.16		5.5°

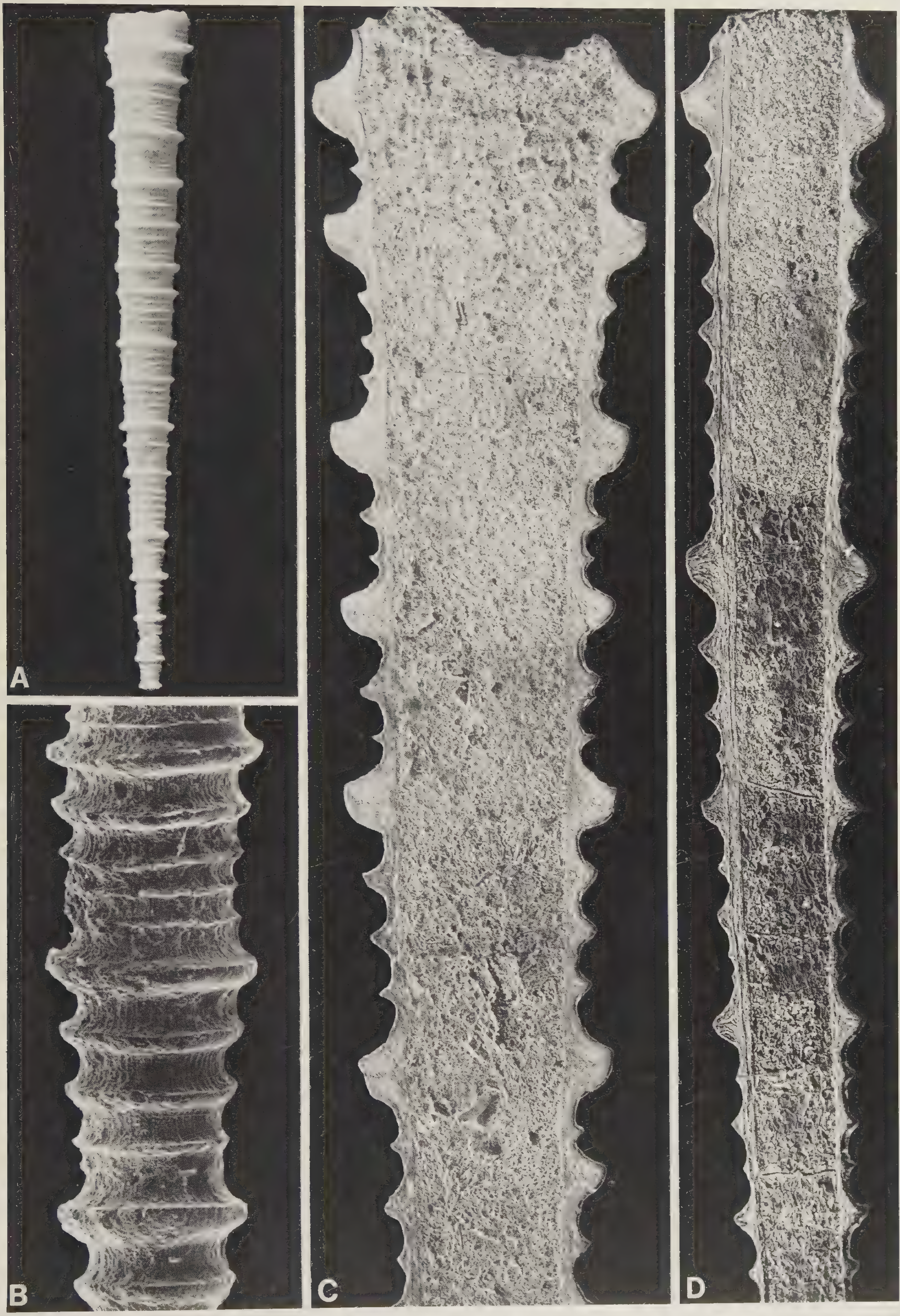
Living chamber slightly conical and symmetrical. Inner wall surface smooth along most of length, distally with slight irregularities if annular concavities incompletely filled. Annular shelves very narrow and poorly developed.

Primary shell, well separated from secondary shell by prominent inner organic layer. No pseudopuncta. Thickness of primary shell 0.01–0.02 mm proximally, increasing gradually to 0.03–0.04 mm distally.

Remarks. – *Dicricoconus acutalis* is characterized particularly by its irregular proximal ring pattern and by the acute secondary rings. The distinctly convexo-concave profile of the primary rings is of considerable significance. The distal ring pattern may occasionally be rather variable in spacing of primary rings and size of the secondary rings. This may sometimes make it difficult to distinguished *Dicricoconus acutalis* from *Turmalites slitiensis*, if the secondary rings of the former species increase gradually in size distally in each primary interspace. However, the latter species has more rounded crests to the rings and a greater proximal curvature.

Occurrence. – *Dicricoconus acutalis* is restricted to the Slite Beds and is rather common in the Slite Marl. It occurs from the Slite Marl, northwestern part up to the *P. gotlandicus* – *A. reticularis* Beds of northeast Gotland. A questionable occurrence at Nygårds 1 may extend the range into the *Pentamerus gotlandicus* Beds of the southwest. It has not been found outside Gotland.

Fig. 58. Dicricoconus acutalis n. sp. ☐ A. Holotype, SMNH X 1126, × 15; Gane 2, G 74-13 KL. ☐ B. Detail of early adult part, SMNH X 1091, × 75; Follingbo 3, MS 485. ☐ C. Longitudinal section of distal part, SMNH X 1133, × 75; Allekvia 1, Got 74-35 SB. ☐ D. Longitudinal section of juvenile part, SMNH X 1139, × 125; sample as for C.


A
B
C
D

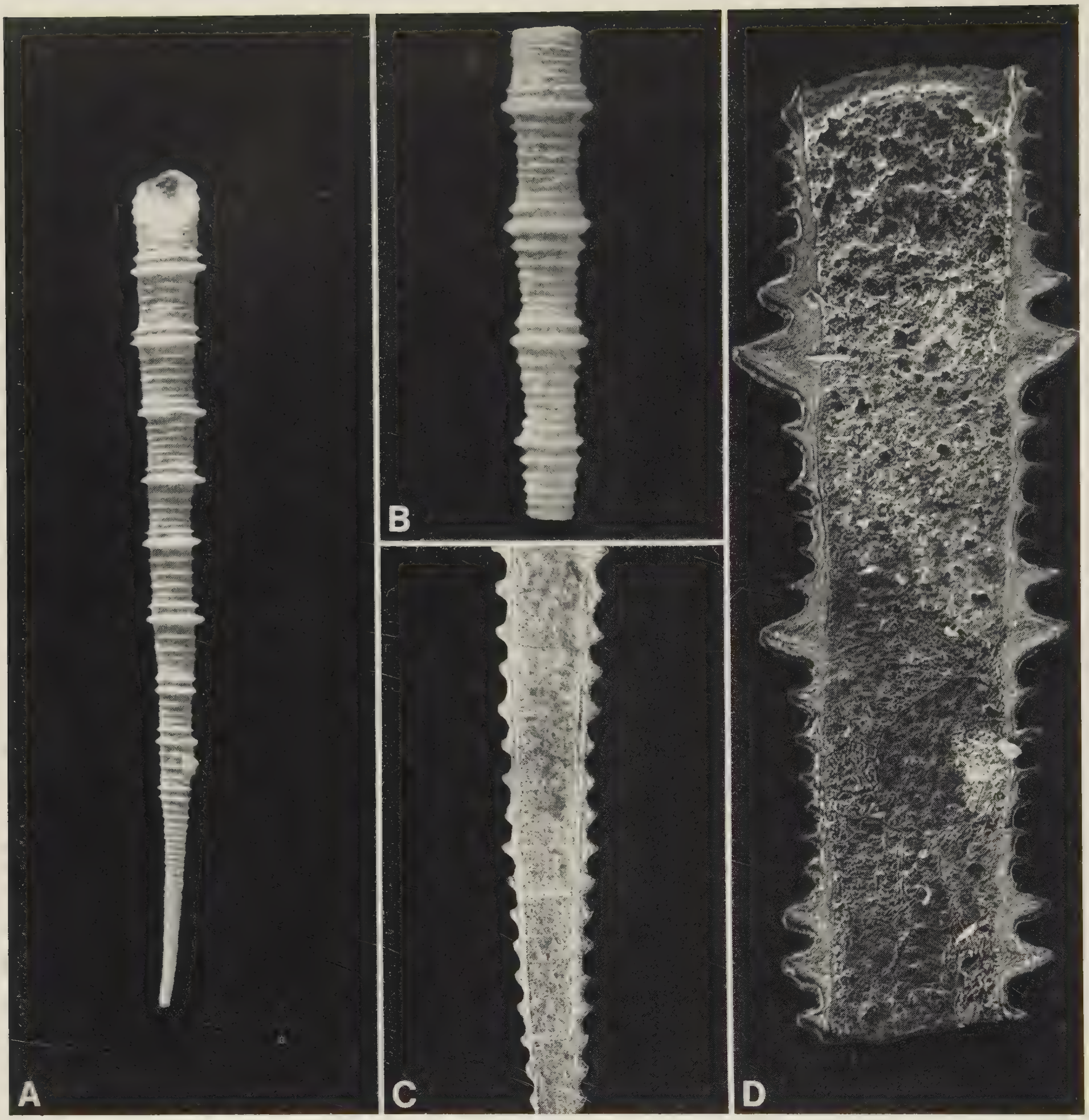


Fig. 59. Dicricoconus aemulus n. sp. B, E, D. Botes 1, G 74-32 KL. ☐ A. Almost complete specimen, LO 4885t, × 25; "Petesviken", unnumbered PDL sample. ☐ B. Holotype, SMNH X 1302, × 25. ☐ C. Longitudinal section of septal region, SMNH X 1309, × 75. ☐ D. Longitudinal section of distal part, SMNH X 1306, × 100.

Dicricoconus aemulus n. sp.

Fig. 59.

Derivation of name. – Latin *aemulus,* striving to equal, referring to the repeated occurrence of a secondary ring immediately following the primary ring of each cycle.

Holotype. – SMNH No. X 1302, Fig. 59B.

Type strata. – Klinteberg Beds, *Klinteberg Marl* (sample G 74-32 KL).

Type locality. – Botes 1, Gotland.

Material. – About 50 specimens from the type locality, 14 specimens from other localities in the Klinteberg Beds, and about 15 specimens from localities in the Hemse Beds.

Diagnosis. – Small-sized slender *Dicricoconus,* growth angle 5°. Straight distally, clearly curved proximally. Annulation proximally with rings of gradually greater size and spacing, distally with widely spaced primary rings each followed directly by one similarly shaped secondary ring and occasionally also preceded by such a ring. Interspaces markedly concave with regular smaller secondary rings.

Table 37. Dicricoconus aemulus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	WLCY	PA
SMNH X 1302 (holotype)	3.13	0.40	0.28	0.75	
SMNH X 1303	2.89	0.36	0.24	0.79	
SMNH X 1304	1.88	0.26	0.18	0.50	5°
SMNH X 1307	6.22	0.42	0.08	1.19	5°
LO 4885 t	5.04	0.40	0.04	0.44	

Description. – Narrow, proximal part expanding at 5°, and distal part at 2–2.5°, gradual change in growth angle immediately proximal of first primary ring. Distinct proximal curvature for ca. 1.50 mm, deflection of proximal end from sagittal plane through living chamber 0.40 mm. Small-sized, estimated full length of 9–10 mm, no initial chamber found. Outer proximal diameter ca. 0.08 mm, outer distal diameter in mature specimens 0.40–0.45 mm, aperture perpendicular to long axis.

Annulation of rings perpendicular to long axis, in two patterns. Proximal part with rings of gradually greater size and spacing distally. Ring density in proximal extreme 40–45 per mm, rapidly decreasing to 20 per mm in middle juvenile region and 15–16 per mm immediately proximal to first primary ring. Rings all almost symmetrical or slightly asymmetrical, axial traces prosocline, profile comparatively angular, crests narrow and well-defined. Distal ring pattern very characteristic; regularly spaced pairs of one primary ring immediately followed by large secondary ring, sometimes ring before primary ring of such size to give ring triplet, with central ring always largest, but proximal ring always slightly further than distal one from primary ring. Spacing of ring pairs or triplets 0.55–0.70 mm, gradually increasing distally. Primary and following secondary ring distinctly raised, height of primary ring 0.07–0.09 mm. Rings slightly asymmetrical; axial traces weakly prosocyrt, most curved close to crest, straighter towards interior. Hinge and crestal lines coincident, profile slightly convexo-concave or convexo-plane, hinge line sharp. Pairs or triplets separated by 5 or 6 regularly spaced rings, within cycles gradual size increase distally, occasionally gradual intital size decrease then increase giving smallest rings in centre. Proximal rings of distal primary interspaces similar to annulets, distal rings clearly secondary rings; transition gradual so distinction of rings and annulets sometimes difficult. Rings similar to those of juvenile part.

Primary interspaces distinctly concave; secondary interspace between primary rings and following secondary ring always narrow, about half basal width of primary ring, interspace preceding primary ring wider and flatter.

Lirae not clearly present. On some specimens very faint longitudinal striation but preservation not permitting further examination.

Proximal septal region; septa perpendicular to long axis, total number unknown because of insufficient material, well spaced 0.20–0.25 mm apart, last septum at outer conch diameter of 0.18 mm but this diameter probably not in mature specimen, free parts of septa straight and thin.

Living chamber with smooth internal wall surface. Primary rings with pronounced thickening of wall, entirely filled by laminae even very close to aperture, lamellar accumulations producing slight constriction of living chamber and slight undulations of wall. No pseudopuncta. Inner organic layer well developed. Thickness of primary shell 0.01–0.015 mm proximally, slightly thicker distally.

Remarks. – *Dicricoconus aemulus* is characterized particularly by the distal ring pattern, especially well seen in specimens from the Klinteberg Marl. Sometimes the distal ring pattern is not so clear and then *D. aemulus* could be confused with *Dicricoconus tenuissimus,* which has a similar juvenile region with a curved conch and rings of gradually greater size and spacing. This problem is marked at some localities slightly higher in Hemse Beds than Eske 1 and Snoder 2 in the northwestern Hemse Marl. At one locality, Burgatan 1, a few conchs have the same general arrangement of the rings as in *D. aemulus.* However, there is little difference between the primary rings and the adjacent secondary rings, and the spacing of the primary rings is wider than is normal in *D. aemulus.* These conchs are tentatively designated *D.* cf. *aemulus.* Similar conchs but with a larger size difference between primary and secondary rings have been found at Gläves 3, well up in the Hemse Marl, southeastern part. These are even more similar to *D. aemulus,* but because of the fragmental and incomplete nature of the material these conchs are referred to *D.* cf. *aemulus.*

Occurrence. – *Dicricoconus aemulus* has a fairly restricted distribution. It is the dominant species of the Klinteberg Marl of the Klinteberg Beds. It extends into the lower Hemse Marl, northwestern part, where only a few, but determinable, specimens have been found at Eske 1, Snoder 1–2 and Lilla Hallvards. The species may extend higher into the Hemse Marl: this is suggested from much fragmented material from Gerete 1, Rangsarve 1, Kullands 1, Amlings 1, and Tänglings 1.

Dicricoconus clintianus n. sp.

Figs. 17D–E, 60.

Derivation of name. – Latin *clintianus,* inhabitant of the Klinte area, referring to the position of the type locality.

Holotype. – SMNH No. X 1262, Fig. 60D.

Type strata. – Slite Beds, Slite Marl, *Pentamerus gotlandicus* Beds (sample G 74-68 KL).

Type locality. – Svarvare 1, Gotland.

Material. – From the type locality, 110 specimens, from additional localities more than 180 specimens.

Diagnosis. – Narrow, medium-sized *Dicricoconus,* expand-

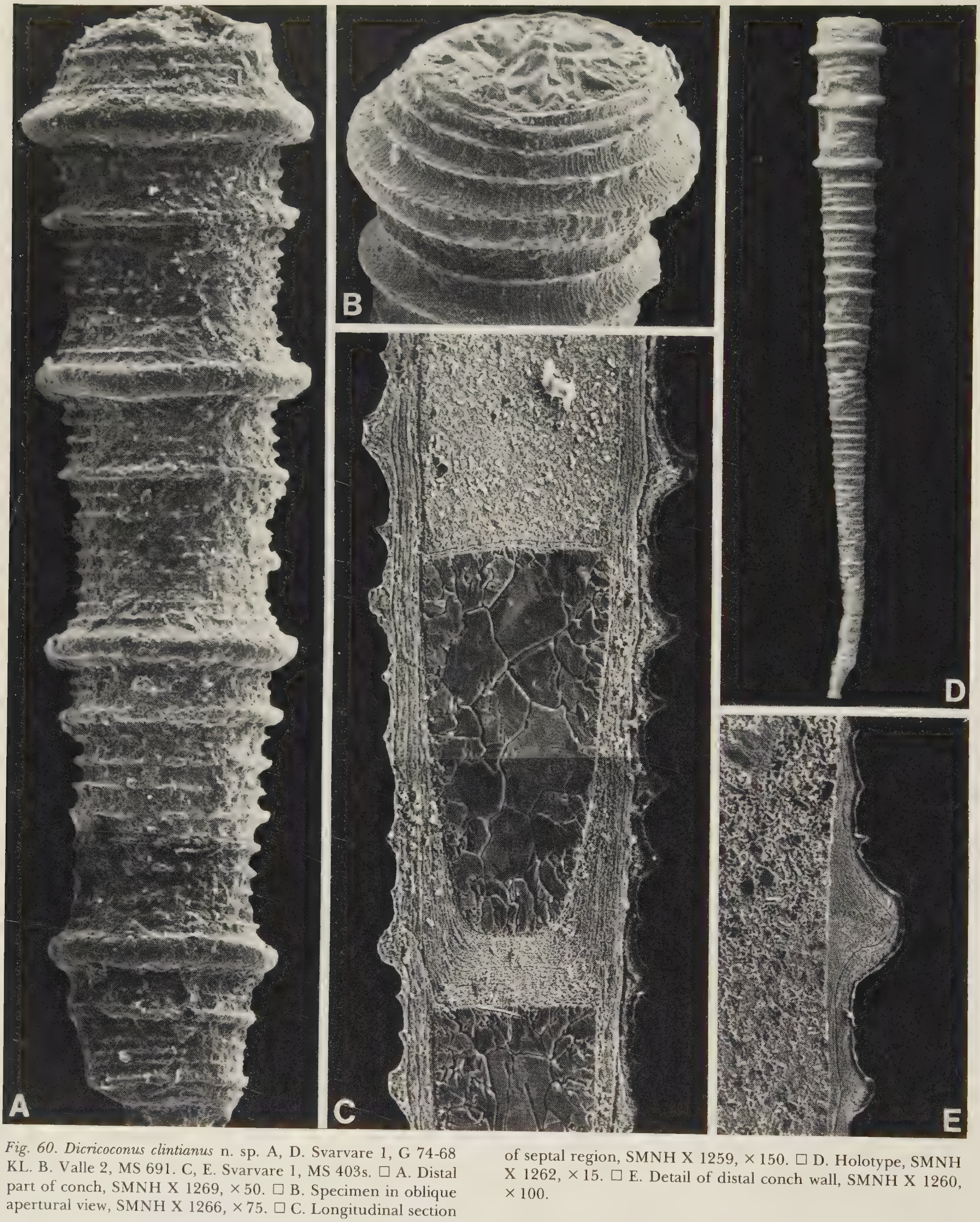


Fig. 60. Dicricoconus clintianus n. sp. A, D. Svarvare 1, G 74-68 KL. B. Valle 2, MS 691. C, E. Svarvare 1, MS 403s. ☐ A. Distal part of conch, SMNH X 1269, × 50. ☐ B. Specimen in oblique apertural view, SMNH X 1266, × 75. ☐ C. Longitudinal section of septal region, SMNH X 1259, × 150. ☐ D. Holotype, SMNH X 1262, × 15. ☐ E. Detail of distal conch wall, SMNH X 1260, × 100.

ing at 4–5°, straight. Ornament of two patterns; proximally with alternating secondary rings and annulets, distally with regularly spaced, distinct primary rings separated by interspaces with one secondary ring and numerous annulets. Rings clearly asymmetrical, profile convexo-concave, hinge lines sharp. Living chamber conical with smooth internal wall surface.

Description. – Narrow, straight, expanding in proximal part at ca. 4–5°, in distal part at the same angle or slightly less. Total length uncertain, estimated at 10–12 mm, no initial chamber found. Outer proximal diameter 0.10–0.12 mm, in mature specimens outer distal diameter 0.80–0.90 mm, aperture perpendicular to long axis.

Ornament of two principal ring patterns. Proximally,

Table 38. Dicricoconus clintianus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	PA
SMNH X 1262 (holotype)	8.16	0.75	0.12	0.59		4°
SMNH X 1259	3.37	0.46	0.28	0.46	0.40	4°
SMNH X 1591	4.95	0.67	0.43	0.63		
SMNH X 1592	4.63	0.71	0.59	0.63		

alternating secondary rings and annulets up to outer diameter of ca. 0.45–0.63 mm, to first primary ring, length up to ca. 6.5 mm. Rings regular, with mostly one, occasionally two or three, annulets in secondary interspaces. Secondary rings increasing gradually in size and spacing distally, density 5 per mm immediately proximal of first primary ring, symmetrical or slightly asymmetrical, axial traces prosocyrt, profile convexo-concave or sometimes cuspate especially in more proximal rings, hinge lines sharp and distinct and forming crestal line. Annulets always symmetrical and cuspate. Distal annulation of primary interspaces with one secondary ring commonly closely proximal of primary rings and generally 0.26–0.30 mm from them, or more central in interspaces, or weakly developed or missing. Annulets in primary interspaces, 6–8 per interspace, density 12–18 rings per mm. Primary rings asymmetrical; axial traces prosocline and prosocyrt in outermost part, gradually becoming orthocline and straight towards interior profile convexo-concave, hinge line comparatively prominent, crests gently rounded. Height: basal width of primary rings 1: 2–2.5.

Distal annulets prominent, symmetrical or asymmetrical, if latter then prosocline and more common towards distal end, bases wide, crests very sharp.

Primary interspaces flat, secondary interspaces distinctly concave.

Lirae well developed, along whole conch occupying tertiary interspaces and distal slopes of rings, sometimes on crests of rings and clearly crossing hinge line of rings, density 6–8 per 0.1 mm.

Proximal septal region with free septa, total septa in mature specimens unknown, last septum at outer diameter of ca. 0.40 mm. Septa spaced 0.40–0.60 mm apart, perpendicular to long axis. Proximal laminae of free parts always straight, in thick septa with many laminae becoming gradually more concave and decreasing in diameter distally, thick septa 0.08–0.10 mm thick, thinnest septa only ca. 0.02 mm thick. Mural parts slightly asymmetrical, decreasing rapidly in thickness mainly in distal laminae of thick septa.

Living chamber is conical and symmetrical with obtuse proximal end. Internal wall surface smooth, thick accumulation of secondary shell material filling annular concavities completely. Proximally, secondary shell well separated from primary shell by thick, persistent inner organic layer. No pseudopuncta. Thickness of primary shell 0.01–0.02 mm proximally, slightly more distally. Total thickness of conch wall 0.05–0.07 mm in the septal region because of additional thickness of mural parts.

Remarks. – The variation of the different characters of *Dicricoconus clintianus* is difficult to assess because the material is fragmented. There is some variation in the spacing of the distal rings, and also in the position and development of the secondary rings. It is particularly well seen in specimens from the Slite Marl. *D. clintianus* has some similarity to *Volynites muldiensis* in the general distal annulation, but has a different ring pattern proximally, denser rings and the frequent development of paired rings. In *Volynites muldiensis* there is some obliquity of rings which never occurs in *Dicricoconus clintianus.* The latter species is also similar to *D. svarvariensis* which occurs in the same samples. *Dicricoconus clintianus* has rings closer together and does not have the widely spaced proximal rings characteristic of *D. svarvariensis.*

Occurrence. – *Dicricoconus clintianus* is the dominant species in the uppermost Slite Beds in *Pentamerus gotlandicus* Beds *sensu* Hede (1927a: 29–39; 1927b: 40–41), but only in the Klintehamn area. It also occurs at some localities in undifferentiated levels of the Slite Marl (e.g. Valleviken 1, Gane 1, Grunnudden 1), Slite Marl, northwestern part (e.g. Follingbo 1–3), and units *f* (Båta 1) and *g* (Spillings 1, Kvarnberget 1, Solklint 1) of the Slite Beds. However, the material from several of these localities is poorly preserved and specific determination may occasionally be questionable.

Dicricoconus cracens n. sp.

Figs. 10A–B, 61.

Synonymy. – □ *Tentaculites* sp. – Fisher 1962: W110, Fig. 55: 8 (*partim*). □ *Tentaculites* (s.l.) n. sp. C – Zagora 1974: 1226, Pl. 4: 4–9.

Derivation of name. – Latin *cracens,* graceful, slender, referring to the conch.

Holotype. – SMNH No. X 1293, Fig. 61A.

Type strata. – Mulde Beds (sample MS 10/1960: VIII).

Type locality. – Mulde Tegelbruk 1, Gotland.

Material. – About 120 specimens from the type locality and 40 specimens from other localities in the Mulde Beds. One specimen from the Halla Beds, unit *b.*

Diagnosis. – Medium-sized, narrow *Dicricoconus* expanding proximal part at 3.5–4°, straight distally, slight proximal curvature. Annulation proximally with asymmetrical secondary rings separated by annulets, distally with prominent, widely spaced asymmetrical primary rings separated by distinctly concave primary interspace with scattered secondary rings and annulets.. Living chamber subcylindrical.

Description. – Very slender, proximal part expanding at 3.5–4°, distally subcylindrical, straight except for moderate proximal curvature for 1.0–1.2 mm, and apical de-

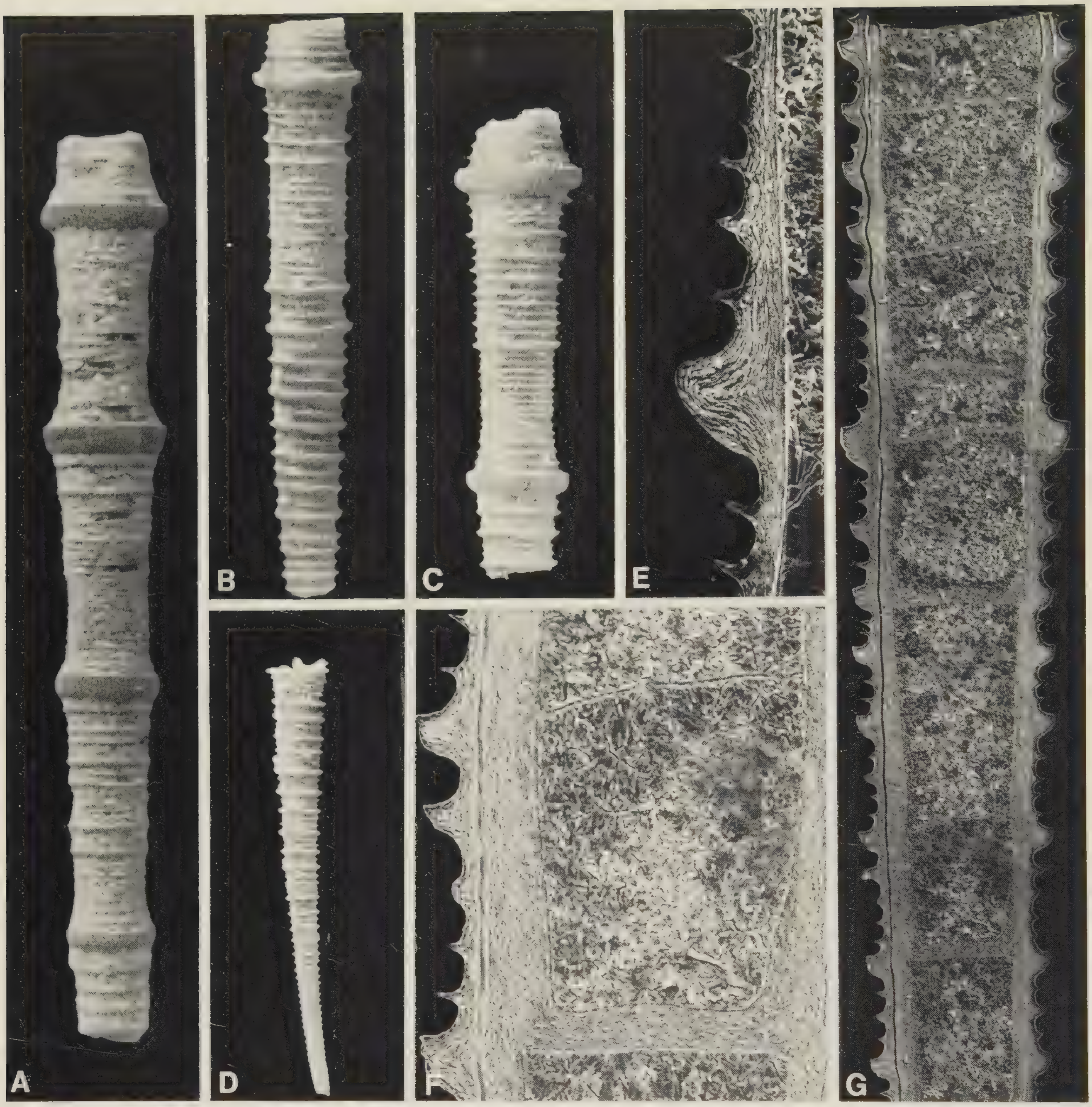


Fig. 61. Dicricoconus cracens n. sp. A. Mulde Tegelbruk 1, MS 10/1960: VIII. B, F, G. Mulde Tegelbruk 1, MS 608. C. Mulde Tegelbruk 1, MS 10/1960: V. D. Mulde Tegelbruk 1, MS 765C. E. Mulde Tegelbruk 1, MS 765A. ☐ A. Holotype, SMNH X 1293, × 25. ☐ B. Specimen showing late juvenile and early adult parts, SMNH X 1297, × 25. ☐ C. Specimen showing adult primary rings and concave primary interspace, SMNH X 1292, × 25. ☐ D. Specimen showing juvenile part, SMNH X 1294, × 25. ☐ E. Longitudinal section of distal conch wall, SMNH X 1287, × 200. ☐ F, G. Longitudinal sections of septa, × 200, and septal region, × 75, SMNH X 1289.

flection from sagittal plane through living chamber of 0.20 mm. Medium-sized, mature adults 13–14 mm long, no initial chamber found. Smallest outer proximal diameter 0.07–0.08 mm, outer distal diameter 0.65–0.70 mm, aperture perpendicular to long axis.

Annulation of two distinct patterns. Juvenile and early adult parts with secondary rings separated by variable numbers of annulets, pattern occupying more than half of conch. Proximal rings small, of equal size and regularly spaced. Spacing and size of rings increasing gradually distally. Proximal ring density 9 per mm, closely proximal of first primary ring 6 per mm. Rings distinctly asymmetrical; axial traces prosocyrt in outermost part, becoming gradually straighter towards interior, curvature of laminae decreasing towards interior until flat and subparallel to long axis. Rings with convexo-concave profile, flattened or gently rounded crests, hinge lines frequently very sharp and occasionally forming minute, but distinct keels. Height of secondary rings 0.01–0.03 mm, height: basal width 1: 1.5–2. Interspaces between secondary rings with 1–4, occasionally 5, annulets, but distal 2–3 mm before first primary ring with only one

Table 39. Dicricoconus cracens n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1293 (holotype)	5.62	0.53	0.44		
SMNH X 1291	9.39	0.59	0.12		3.5°
SMNH X 1294	2.69	0.32	0.08		4°
SMNH X 1300	5.23	0.51	0.16	0.40	4°
SMNH X 1301	4.24	0.48	0.24	0.30	3.5°

annulet per interspace, in many specimens conch adjacent to this ring lacking secondary rings and only with annulets. Annulets symmetrical or prosocline and prosocyrt, in a few specimens opisthocline and opisthocyrt, although comparatively rarely. Height of annulets 0.01–0.02 mm.

Distal pattern of cycles of well-spaced rings with numerous annulets, spacing of primary rings 1.50–2.20 mm, attitude and shape similar to proximal secondary rings, height 0.08–0.10 mm. Secondary rings in each primary interspace few, smaller but with similar attitude and shape as those proximally, mainly in distal half of interspace but occasionally also proximal or central. Some specimens with alternating secondary rings and annulets in distal half of interspace. Annulets per primary interspace 15–25, density 20–25 per mm, both number and density very variable, opisthocline or slightly prosocline and prosocyrt, height 0.03–0.04 mm.

Proximal primary interspaces flat or slightly concave, secondary interspaces always clearly concave; distal primary interspaces characteristically concave and elognate, secondary interspaces also pronouncedly concave.

Lirae very poorly developed; hardly traceable in proximal part, weakly developed distally, best seen (but still weakly developed) on crests of primary rings and extending a short distance proximally from hinge line. Density 6–7 per 0.1 mm. Proximal slopes of rings always without lirae.

Proximal septal region; septa numerous, up to 15–20, closely spaced, generally 0.15–0.30 mm apart. Last septum at outer conch diameter of 0.40–0.45 mm but specimens probably not fully mature. Free parts straight, perpendicular to long axis, thickness mostly 0.01–0.04 mm but some also very thin. 0.001 mm. Thin septa between thicker septa, occasionally slightly convex. Mural parts moderately long, generally asymmetrical, of same initial thickness as free parts but gradually thinning after 1 mm, in strongly asymmetrical septa parts already wedging out after 0.2–0.3 mm.

Living chamber subcylindrical with blunt proximal end. Internal wall surface remarkably smooth along whole chamber. Annular concavities completely filled and lamellae accumulation frequently so great to produce slight constrictions at primary rings; filling of rings obviously rapid during ontogeny because all specimens having intact aperture also with smooth internal wall surface up to rim of aperture, and thus, annular shelves very short-lived.

No pseudopuncta. Proximally, secondary shell distinctly separated from primary shell by thick, very persistant, inner organic layer up to 0.008 mm thick. Thickness of primary shell 0.01–0.02 mm proximally, slightly thicker distally.

Remarks. – The ring patterns are fairly constant. Minor variations may be observed in the development of the portion immediately before the first primary ring, which may either lack secondary rings or have rings alternating with one annulet per interspace. Length of distal primary interspace and number of secondary rings in these interspaces may vary.

Dicricoconus cracens is easily distinguished from all other tentaculitids on Gotland, primarily by its characteristic distal ring pattern and the concave primary interspaces. The proximal ring pattern shows some resemblance to that of *Volynites muldiensis,* but the septal development and shape of the rings are different, and the conch is much slenderer in *D. cracens.*

Occurrence. – *Dicricoconus cracens* has a restricted distribution, both geographically and stratigraphically. It occurs in the lower Mulde Beds at a few localities, but also in the Halla Beds, unit *b,* where a single specimen was found at Hörsne 1.

Dicricoconus gutnicus n. sp.

Figs. 12A, 62.

Derivation of name. – Latin *Gutnicus,* inhabitant of Gotland.

Holotype. – SMNH No. X 1096, Fig. 62A.

Type strata. – Slite Beds, *Slite Marl* (sample G 73-60 KL).

Type locality. – Myrse 1, Gotland.

Material. – From the type locality 5 specimens, from additional localities 171 specimens.

Diagnosis. – Small, proximal growth angle of 5–7°, straight distally, slight proximal curvature. Annulation perpendicular to long axis, of widely and regularly spaced, well developed rings separated by wide, flat interspaces with numerous annulets. Proximal rings more irregular, occasionally missing. Proximal septal region with few septa.

Description. – Narrow, proximal part expanding at 5–7°, distal part at 1–2°, straight except for slight proximal curvature. Small, estimated full size of 6.5–7.0 mm, no initial chamber found. Smallest outer proximal diameter ca. 0.08 mm, outer distal diameter 0.55–0.60 mm, aperture perpendicular to long axis.

Ornament of well-developed rings, mostly of one size, widely spaced, size and spacing increasing gradually distally. Proximal rings occasionally slightly irregular sometimes paired or missing. Occasionally distinction of rings from annulets difficult. Adult part with one or, rarely, two secondary rings immediately proximal of primary ring. Rings mostly symmetrical but may be

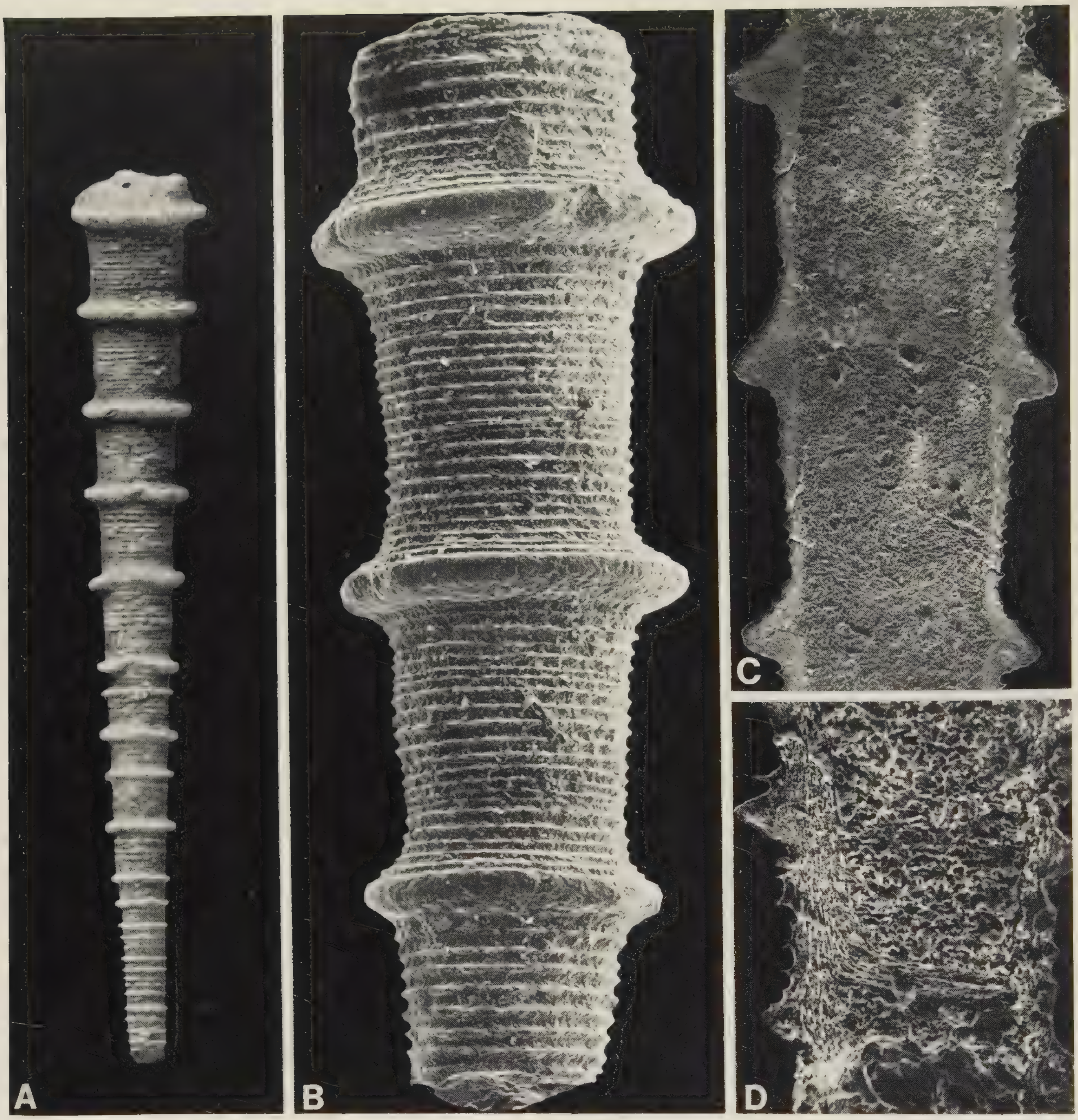


Fig. 62. Dicricoconus gutnicus n. sp. □ A. Holotype, SMNH X 1096, × 25; Myrse 1, G 73-60 KL. □ Distal part of conch, SMNH X 1105, × 75. □ C. Longitudinal section of distal part, SMNH X 1106, × 70. □ B, C – Allekvia 1, Got 74-35 SB. □ D. Detail of last septum in longitudinal section, SMNH X 1107, × 200; Follingbo 7, Got 74-28 SB.

slightly asymmetrical and opisthocline, axial traces generally straight. Rings rounded, sometimes angular especially in juvenile part. Height of distal rings normally 0.10–0.15 mm, height: basal width 1: 1.2–1.5.

Primary rings separated by wide, flat interspaces with numerous annulets. Annulets proximally 5–8 per interspace, distally 14–16 per interspace, also on distal slopes of rings but proximal slopes always smooth, slightly denser in proximal half of interspace but also many interspaces with regularly spaced annulets, symmetrical, angular or cuspate in profile, height 0.01–0.015 mm. No lirae.

Proximal septal region with few, symmetrical septa, in general 3–4. Last septum at outer conch diameter of 0.25–0.27 mm, commonly with concave free part and long mural part extending distally for 1.0–1.2 mm. Proximal septa with straighter free parts but mural parts about same length as last septum. Thickness of septa 0.01–0.03 mm. In a few specimens septa slightly endoconic.

Living chamber slightly conical and symmetrical with rounded proximal end. Internal wall surface almost smooth but occasionally with some annular concavities with very weak annular shelves.

No pseudopuncta. Thickness fairly uniform along whole conch, increasing gradually from 0.025 mm proximally to 0.035 mm distally.

Table 40. Dicricoconus gutnicus n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	PA
SMNH X 1096 (holotype)	5.70	0.63	0.24		5°
SMNH X 1097	5.78	0.43	0.14	0.24	6°
SMNH X 1099	3.37	0.43	0.12		7°
SMNH X 1101	4.59	0.55	0.22	0.27	7°
SMNH X 1102	3.45	0.48	0.22		5°
SMNH X 1103	4.83	0.45	0.10		6°
SMNH X 1109	3.56	0.45	0.08		6°

Remarks. – Some variation in the proximal ring pattern has been noted in *Dicricoconus gutnicus.* A number of specimens from various localities lack rings along much of the juvenile part or rings may be paired. Distally, the ring pattern is rather stable. Some variation may occur in the development of the septa. *Dicricoconus gutnicus* is easily recognized from all other species by its characteristic distal ring pattern. Thus, very small fragments of the conch can be determined. Proximally, *Dicricoconus acutalis* may shows some resemblance to *D. gutnicus,* but the former species has less annulets per interspace and its rings are sharper.

Occurrence. – *Dicricoconus gutnicus* is restricted to the Slite Marl of the Slite Beds. It occurs in a narrow area of Slite Marl from Sudersandsviken 1 in the northeast to Valbytte in the southwest. One specimen has been found in unit *g* of the Slite Beds (Solklint 1). It has not so far been found outside Gotland.

Dicricoconus svarvariensis n. sp.

Figs. 17F, 63.

Derivation of name. – Latin *Svarvariensis,* from Svarvare, referring to the type locality.

Holotype. – SMNH No. X 1263, Fig. 63C.

Type strata. – Slite Beds, *Slite Marl, Pentamerus gotlandicus* Beds (sample G 74-68 KL).

Type locality. – Svarvare 1, Gotland.

Material. – From the type locality 26 specimens, from additional localities 27 specimens.

Diagnosis. – Straight, slender, narrow *Dicricoconus,* proximal part expanding at 4°, distally subcylindrical. Annulation of widely spaced primary rings separated by 3–6 secondary rings and one annulet per secondary interspace. Rings distinctly asymmetrical, with convexo-concave profile, sharp hinge lines, flat or slightly rounded crest. Lirae well developed in tertiary interspaces, crossing annulets and hinge linges of rings. Proximal septal region with irregularly spaced and shaped septa.

Description. – Straight and slender, proximal part expanding at ca. 4°, distally subcylindrical. Maximum length of fully adult specimens estimated as 10–11 mm, no initial chamber found. Smallest outer proximal diameter ca. 0.16 mm, outer distal diameter in adult specimens 0.75–0.85 mm, aperture perpendicular to long axis.

Ornament of rings and annulets perpendicular to long axis, rings in cycles. Proximal rings regularly spaced with density of 10–12 rings per mm. Late juvenile and adult parts with well spaced primary rings, initially 0.65–0.70 mm apart, distally 1.50–2.70 mm apart. Primary interspaces with 3–6 regularly spaced secondary rings of one size, secondary interspaces smooth or with mostly one, rarely two annulets.

Primary rings distinctly asymmetrical, axial traces prosocline and prosocyrt in outermost part but more opisthocline and straight towards interior profile convexo-concave, hinge line very sharp, crests flat or slightly rounded. Height of distal rings ca. 0.8 mm, height: basal width 1: 2.0–2.5.

Secondary rings with similar attitude and shape to primary rings, but much thinner and lower, distally ca. 0.3 mm high.

Annulets in secondary interspaces, sparse, normally only one per interspace, central. Asymmetrical, with narrow, pointed crests, normally strongly prosocyrt.

Secondary interspaces comparatively flat. Lirae over whole conch, distinct, occurring in tertiary interspaces, crossing crests of annulets and commonly also crests of rings. Only lower proximal slopes of rings entirely smooth. Occasionally but not generally, lirae with distinct median furrow. Density 7–8 per 0.1 mm.

Proximal septal region with free, slightly asymmetrical septa spaced irregularly. Free parts irregularly undulating, mural parts long and initially same thickness as free parts, total septa not possible to establish.

Living chamber subcylindrical with blunt proximal end. Internal wall surface smooth.

Primary shell distinctly separated from secondary shell by thick inner organic layer. No pseudopuncta. Thickness of primary shell 0.01–0.02 mm proximally, increasing gradually to ca. 0.03–0.04 mm distally.

Remarks. – *Dicricoconus svarvariensis* much resembles *D. acutalis* in size, general mode of the ring pattern, shape and attitude of the rings and development of the septa. The two species may be differentiated by the wider spacing of the primary rings in *D. svarvariensis,* and on the development of annulets in the secondary interspaces, *D. svarvariensis* always has several or all interspaces each with one central annulet, while *D. acutalis* lacks or has very few annulets in the secondary interspaces. Another distinguishing character is the development of the lirae: in *Dicricoconus svarvariensis* but never in *D. acutalis* these occur on the crests of rings. *Dicricoconus svarvariensis* shows similarities to *D. clintianus;* distinction of these two species is discussed in the description of *D. clintianus.*

The intraspecific variation can only be considered broadly because the available material is sparse and fragmented. Variation in spacing of the primary rings

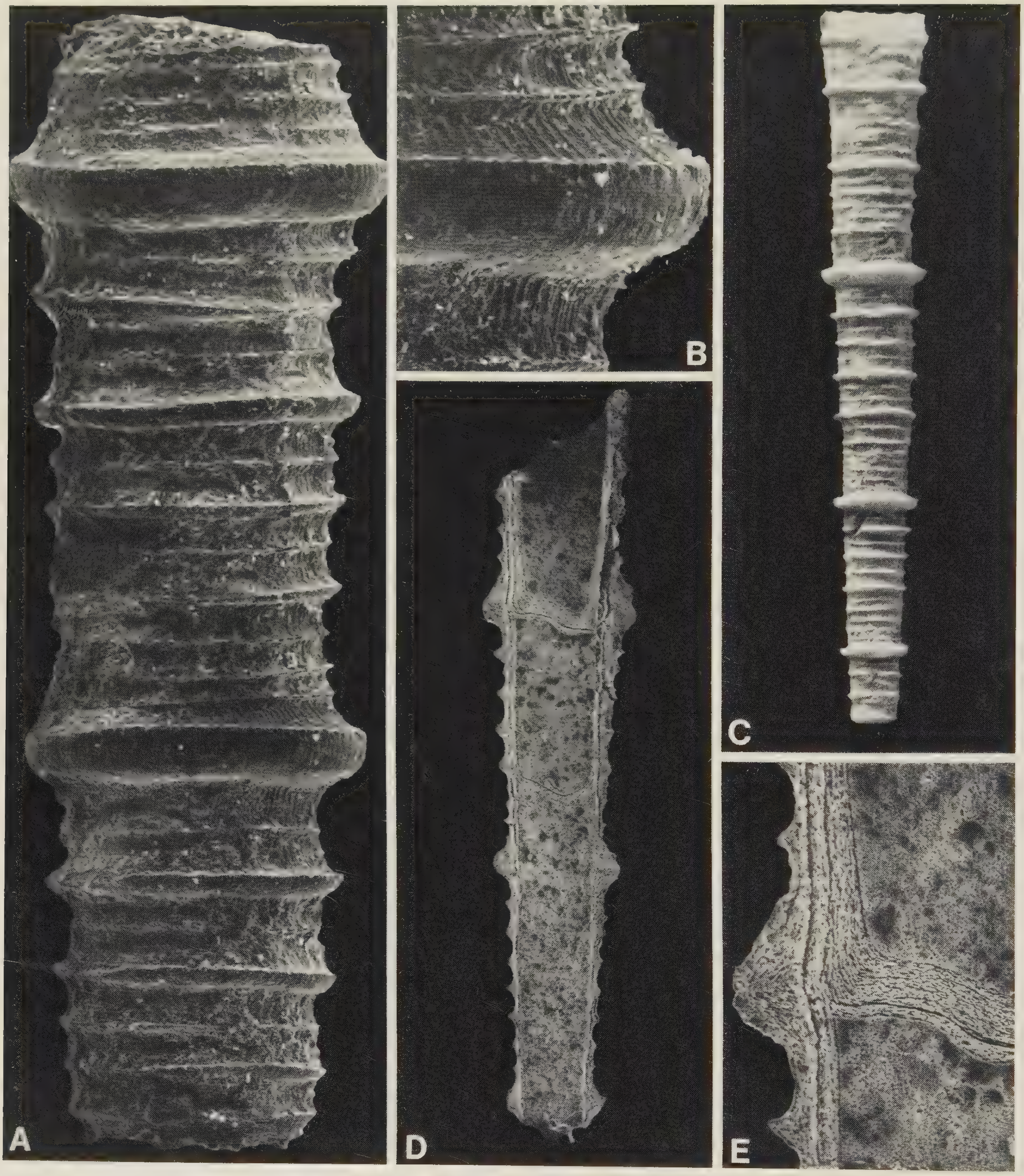


Fig. 63. Dicricoconus svarvariensis n. sp. ☐ A, B. Distal part of conch, ×60, and detail of primary ring, ×125, SMNH X 1604; Svarvare 1, G 75-3 MB. ☐ C. Holotype, SMNH X 1263, ×25; Svarvare 1, G 74-68 KL. ☐ D, E. Longitudinal section of septal region, ×60, and detail of septum, ×175, SMNH X 1605; sample as for A, B.

and in spacing and development of the septa seems common. The size of the secondary rings seems variable, which often makes it difficult to distinguish these rings from annulets, except in section.

Occurrence. – *Dicricoconus svarvariensis* occurs sparsely in the uppermost Slite Beds, i.e. the Slite Marl, *Pentamerus gotlandicus* Beds. It has so far only been found at localities in the Klintehamn area on Gotland.

Table 41. Dicricoconus svarvariensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODLS	WLCY	PA
SMNH X 1263 (holotype)	4.79	0.63	0.28			
SMNH X 1264	5.86	0.59	0.16			
SMNH X 1603	1.86	0.35	0.22	0.34		
SMNH X 1681	6.93	0.59	0.20		1.78	4°
SMNH X 1682	7.84	0.67	0.24		2.69	4°

Dicricoconus tenuissimus (Hede 1919)
Fig. 64.

Synonymy. – ☐ *Tentaculites tenuissimus* n. sp. – Hede 1919b: 129–130, Pl. 5: 6. ☐ *Tentaculites* n. sp. – Hede 1919a: 11 (foot-note). ☐ *Tentaculites* n. sp. – Hede 1919c: 28. ☐ *Tentaculites* n. sp. 6 – Hede 1921: 59, 64.

Holotype. – LO 3761T, figured in Hede (1919b, Pl. 5: 6), herein Fig. 64A.

Type strata. – *Colonus* Beds, middle part.

Type locality. – Skarhult 1, Scania.

Material. – In addition to the holotype, 12 specimens from the type locality. From the Hemse Beds of Gotland about 550 specimens.

Diagnosis (emended herein). – Narrow, proximal part expanding at 5°, distal part at 2–3°, small-sized, distal part straight, proximal curvature. Annulation perpendicular to long axis, in two patterns; proximally with rings of one size, gradually increasing distally in size and spacing, distally with widely, irregularly spaced primary rings separated by numerous secondary rings.

Description. – Slender, proximal part expanding at 5°, distal part at 2–3°, gradual change in growth angle near first primary ring. Distal part straight, slight proximal curvature for ca. 1 mm, maximum deflection of proximal end from sagittal plane through living chamber 0.15 mm. Small, maximum length 7–8 mm, no initial chamber found. Smallest outer proximal diameter 0.04–0.05 mm, outer distal diameter 0.40–0.50 mm, occasionally 0.55 mm, aperture perpendicular to long axis.

Rings of two sizes in two patterns. Proximal part with rings of one size, gradually increasing in size and spacing towards the first primary ring. Proximal rings dense, about 30 per mm, immediately proximal of first primary ring 18 per mm. Most rings of such size and construction to be designated secondary rings. Rings orthocline or faintly prosocline, axial traces frequently prosocyrt, profile convexo-concave, crests fairly sharp. Height: basal width 1: 0.6–0.7. Distal conch with cycles of primary rings separated by numerous secondary rings. First primary ring ca. 3.20–3.30 mm from apex, at outer diameter of 0.20–0.30 mm. Primary rings widely spaced, 0.45–1.10 mm apart, without increase of spacing distally, rather, short cycles may follow longer cycles. Primary rings asymmetrical, axial traces prosocline and prosocyrt in outermost part becoming gradually more planar and orthocline towards interior, profile distinctly convexo-concave or convexo-plane, crests slightly rounded, hinge line fairly distinct, slopes of rings smooth. Height of primary rings 0.05–0.06 mm, height: basal width 1: 1.3–1.5.

Secondary rings occupying primary interspaces, 5–15 depending on length of interspaces. Mostly clearly rings but sometimes those most proximal in each cycle more like annulets. Rings regularly spaced, density 12–14 per mm, mostly asymmetrical with prosocline and prosocyrt attitudes but sometimes orthocline or even prosocline with opisthocyrt axial traces. Strongest curvature of axial trace generally outermost in rings. Secondary rings generally with convexo-concave profile, hinge lines sharp.

Primary interspaces straight, secondary interspaces always clearly concave.

No clear evidence of lirae. A few specimens with some indistinct minute structures on primary ring crests, but preservaton insufficient for further examination.

Proximal septal region: total septa and normal position of last septum unknown because no fully mature specimens available for sectioning. Septa fairly widely spaced. 0.40–0.60 mm apart. Free parts perpendicular to long axis, straight or slightly convex. Mural parts long and occasionally slightly asymmetrical. Thickness of free parts and early mural parts the same, ca. 0.01 mm.

Living chamber in mature specimens straight, conical or sybcylindrical. Internal wall surface smooth along whole chamber to rim of aperture. Annular concavities completely filled, lamellar accumulation sometimes so great that living chamber slightly constricted.

No pseudopuncta. Thickness of primary shell 0.003–0.005 mm proximally, 0.006–0.009 mm distally. Secondary shell increasing proximal thickness 3–4 times, distal thickness almost doubled.

Remarks. – *Dicricoconus tenuissimus* was described briefly by Hede (1919b) from Skarhult, Scania, as *Tentaculites tenuissimus* n. sp. His description was based on a specimen which showed only the proximal conch with regularly spaced rings of similar size and shape. The rings were described as sharp crested. The tentaculitid material at Skarhult is unfortunately very fragile, especially that in weathered limestone slabs. Thus, the outermost laminae exfoliate easily, which makes sharper the outline of the rings. Further preparation by needle of the holotype, to remove matrix from the two most proximal primary rings has confirmed that this specimen is conspecific with material obtained from the Hemse Beds of Gotland. *D. tenuissimus* was first mentioned from Gotland in 1919, when Hede described briefly, but without any accompanying illustration, *Tentaculites* n. sp. from the NW part of the Hemse Marl. The species was referred to as typical for the "Petesvik-Hablingbo fauna". It was described in a foot-note (1919a: 11) as having a slender, slightly expanding conch with 5 or 6 rounded, regularly spaced rings separated by 8–15 smaller rings. In Hede (1919c), the same species was mentioned from the borehole Burgsvikborrningen 1 between 121.19 m to 71.13 m. Subsequently it was referred to as *Tentaculites* n. sp. 6 in Hede (1921), where it was reported from the Hemse, Eke, Burgsvik and Hamra Beds. However, it is clear from the present study that it is restricted to the Hemse Beds.

Dicricoconus tenuissimus is closely related to *D. aemulus*, but differs by not having a larger secondary ring immediately following each primary ring, and by having wider interspaces. The difference is most conspicuous in the distal conch: the proximal parts, up to the first primary ring could easily be confused.

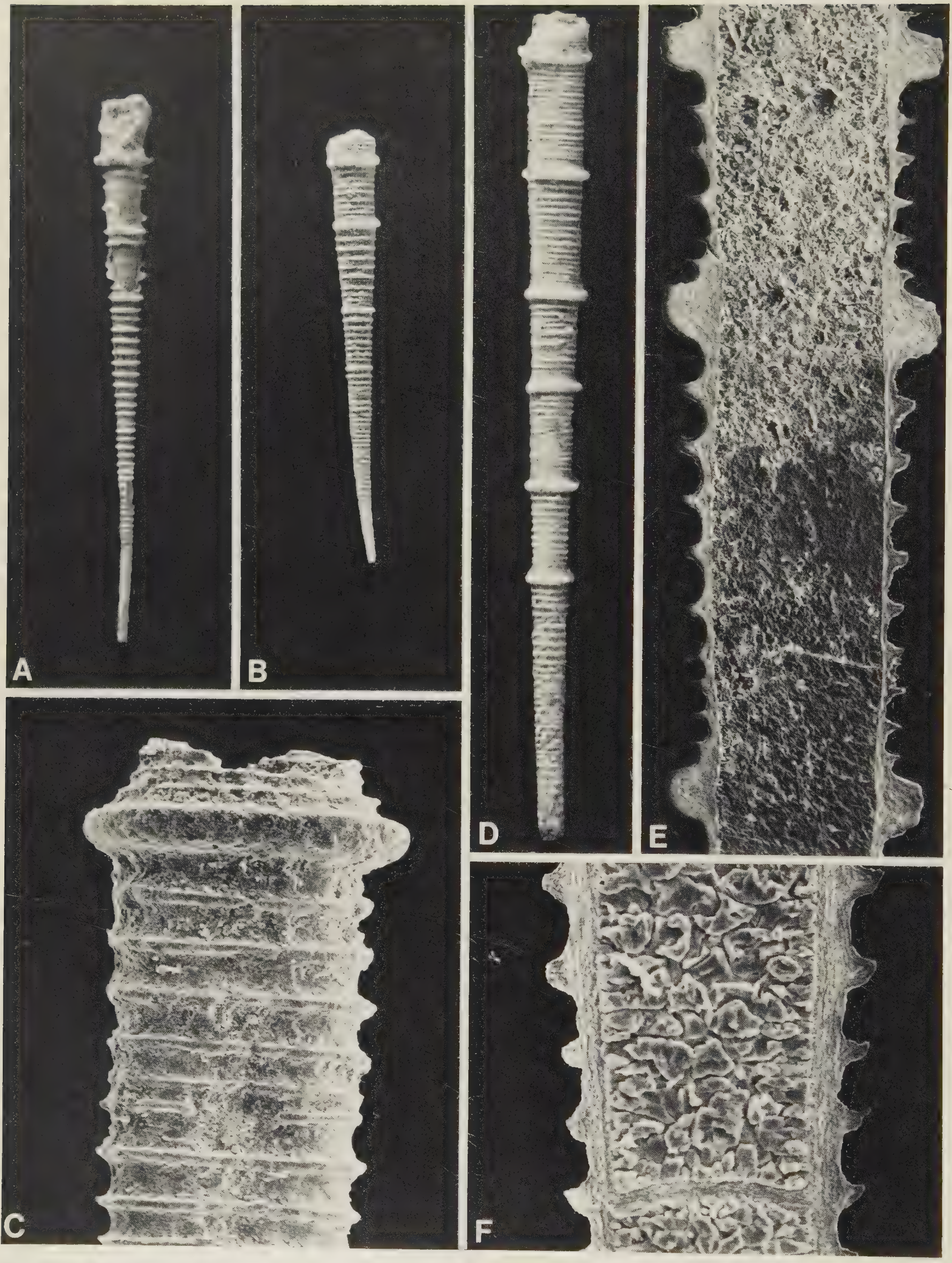


Fig. 64. Dicricoconus tenuissimus (Hede). ☐ A. Holotype, LO 3761T, ×25: Skarhult 1. ☐ B. Young individual, SGU type collection, ×25; Burgsviksborrningen 1, 74.02 m. ☐ C. Specimen showing distal primary ring and primary interspace, SMNH X 1321, ×100; Kodings 3, G 75-6 KL. ☐ D. Adult specimen with broken juvenile part, SGU type collection, ×20; Hallsarve 2, unnumbered SGU sample. ☐ E. Longitudinal section of adult part, SMNH X 1320, ×100; sample as for C. ☐ F. Longitudinal section of septal region, SMNH X 1322, ×900; Tjängdarve 1, G 75-10 KL.

Table 42. Dicricoconus tenuissimus (Hede) (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	ODLS	PA
LO 3761 T (holotype)	3.56	0.24	0.06	0.20		4°
LR 1	3.17	0.32	0.16	0.24		5°
SMNH X 1311	3.09	0.28	0.06	0.28		5°
SMNH X 1314	4.12	0.32	0.10	0.20	0.30	
SMNH X 1315	3.84	0.36	0.06	0.26		4°
SMNH X 1316	3.48	0.30	0.04	0.26		5°
SGU Te 32	7.12	0.50	0.20	0.28		

Occurrence. – In Scania, *Dicricoconus tenuissimus* (Hede) has been found at Skarhult 1, where it is abundant in the middle *Colonus* Beds. A few poorly preserved fragments have been identified from section 3_{c2} at Röddinge 1 (Moberg & Törnquist 1908) in beds of similar age to Skarhult 1. On Gotland, the species ranges from the Hemse Marl, northwestern part, up to the top Hemse Beds. In the borehole Burgsvikborrningen 1 (Hede 1919c), it occurs from 121.19 m up to 71.13 m, i.e. 7.63 m below the Burgsvik-Eke Beds boundary. *Dicricoconus tenuissimus* is the dominant species in the Petesvik-Hablingbo area, but it is also abundant in samples from the Hemse Beds, southeastern part, e.g. at Kodings 1–4, Tjängdarve 1, and in the uppermost Hemse Beds, e.g. at Draksarve 1, Jakobs 1, and Hallsarve 2. It has not been found in beds with *Neobeyrichia lauensis* nor in the *Dayia* flags.

Dicricoconus valliensis n. sp.

Fig. 65.

Derivation of name. – Latin *Valliensis,* from Valle, referring to the type locality.

Holotype. – SMNH No. X 1599, fig. 65A–B.

Type strata. – Slite Beds, *Slite Marl, Pentamerus gotlandicus* Beds (sample G 74-39 KL).

Type locality. – Valle 1, Gotland.

Material. – From the type locality 30 specimens, from additional localities in the Slite Beds about 30 specimens.

Diagnosis. – Slender, straight *Dicricoconus* with proximal growth angle of 5°, distally subcylindrical. Annulation distinct, perpendicular to long axis, mainly of few primary rings and numerous, regularly spaced secondary rings. Rings asymmetrical with sharp hinge lines; primary rings with rounded crests, secondary rings with sharp, pointed crests. Interspaces concave. Lirae well developed, crossing hinge lines of rings and on crests of primary rings. Septa not observed in material available but probably present.

Description. – Straight and slender, proximal part expanding at 5°, distally subcylindrical. Material available badly fragmented but adult size tentatively estimated as 8–10 mm, no initial chamber found. Smallest outer proximal diameter 0.08 mm, outer distal diameter 0.60–0.65 mm, aperture perpendicular to long axis.

Ornament of regularly spaced rings and annulets perpendicular to long axis. Primary rings spaced ca. 0.8 mm apart, first primary ring normally at outer conch diameter of ca. 0.50 mm. Secondary rings forming proximal annulation, and normally 3 or 4 between primary rings. Density of secondary rings ca. 28 per mm at conch diameter of 0.10 mm, ca. 6 per mm immediately before first primary ring.

Rings clearly asymmetrical, with straight or slightly prosocyrt axial traces, convexo-concave profile, sharp hinge lines. Primary rings with rounded crests, secondary rings with sharp crests because crestal and hinge lines coincident. Height of distal primary rings ca. 0.1 mm, height: basal width 1: 1.8–2.0.

Annulets very few, normally scattered in secondary interspaces or in only one in that secondary interspace immediately following a primary ring. Secondary interspaces otherwise smooth and clearly concave.

Lirae over whole conch, frequently crossing crests of rings and on crests of primary rings, density 7–8 per 0.1 mm.

Material available not permitting study of septal development, but no reason to believe septa to be missing.

Living chamber symmetrical, subcylindrical. Internal wall surface smooth. Some specimens with irregular wall surface proximally, but these are probably juvenile or early adult specimens before septal growth or where septa were too short distally for smoothing of the conch wall by attachment of mural parts to have occured.

No pseudopuncta. Thickness of conch wall ca. 0.01 mm proximally, ca. 0.03 mm distally.

Remarks. – From the material available it is difficult to gauge satisfactorily the intraspecific variation. There seems to be some variation in the size, spacing and development of the primary rings.

Dicricoconus valliensis is characterized particularly by the sharp, distinct, and proximally regular secondary rings. Another characteristic is the concave secondary interspaces.

The general ring pattern resembles to some extent those of the associated species *D. svarvariensis* and *D. clintianus.* However, the concave interspaces and the sharp, regularly spaced secondary rings differentiate *D. valliensis* from these species.

Occurrence. – *Dicricoconus valliensis* is restricted to the *Pentamerus gotlandicus* Beds – *Atrypa reticularis* Beds of the Slite Beds on Gotland. It has been found mainly in the Klintehamn area, where it occurs rather sparsely.

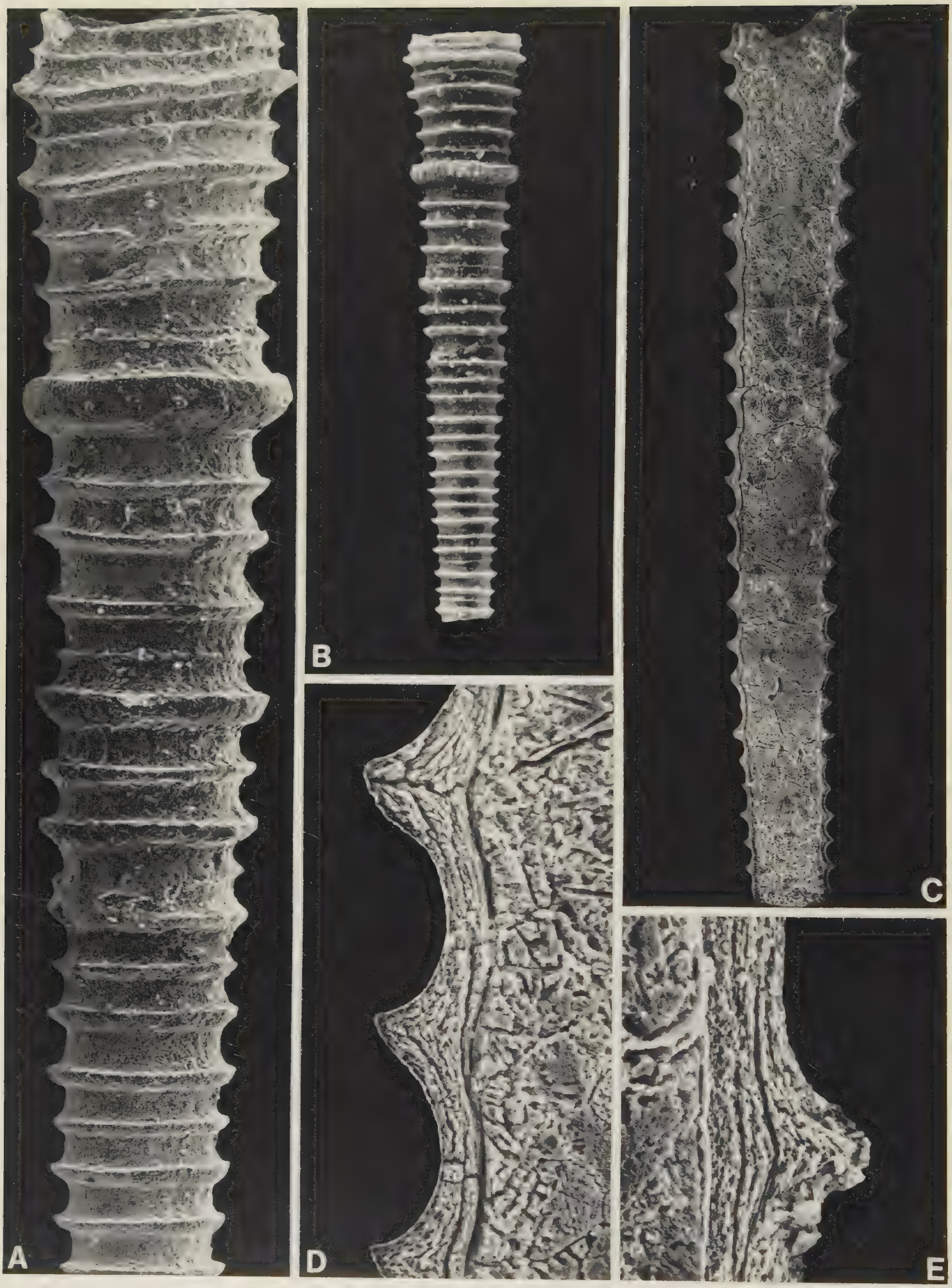


Fig. 65. Dicricoconus valliensis n. sp. A–E Valle 1, G 74-39 KL. ☐ A, B. Holotype distal part, × 60, and full view, × 25, SMNH X 1599. ☐ C, D. Longitudinal sections of early adult part, × 60, and detail of conch wall, × 300, SMNH X 1607. ☐ E. Detail of conch wall with secondary ring, SMNH X 1606, × 600.

Table 43. Dicricoconus valliensis n. sp. (dimensions in mm).

Spec. No.	DEEC	ODID	OPRD	ODFR	PA
SMNH X 1599 (holotype)	4.23	0.57	0.32	0.49	5°
SMNH X 1600	2.20	0.24	0.08		5°
SMNH X 1601	2.77	0.55	0.40	0.51	

Family Gotlandellitidae n. fam.

Type genus. – *Gotlandellites* n. gen.

Genera. – Only the type genus.

Diagnosis. – Small, 3–5 mm long, strongly curved, proximal part expanding at 4–7°. Aperture perpendicular or slightly oblique to long axis. Rings alike in shape, sloping slightly towards convex side of conch, increasing gradually in size and spacing distally. Primary interspaces flat or slightly concave, covered with annulets variable in size and number. Lirae weakly developed, on distal slopes of rings. Proximal septal region. Mural parts of septa long. Internal wall surface of living chamber smooth proximally, smooth or slightly irregular distally. No pseudopuncta.

Remarks. – The family differs from all other families known by the pronounced curvature of the conch. The small size is also significant.

Stratigraphical distribution. – Upper Llandoverian and lower Wenlockian.

Geographical distribution. – Sweden (Gotland), Great Britain (Wales, Shropshire), Canada (Anticosti Island).

Genus *Gotlandellites* n. gen.

Derivation of name. – Latin *Gotlandellites,* small inhabitant of Gotland.

Type species. – *Gotlandellites visbyensis* n. sp.

Species. – *Gotlandellites areolatus* n. sp. and *G. visbyensis* n. sp.

Diagnosis. – As for the family.

Remarks. – The genus differs from all other genera known by its pronounced curvature of the conch. The ornament is similar to that of *Tentaculites* von Schlotheim, with regularly spaced rings separated by annulets in the interspaces.

Stratigraphical distribution. – As for the family.

Geographical distribution. – As for the family.

Gotlandellites areolatus n. sp.

Fig. 66.

Derivation of name. – Latin *areolatus,* with small spaces, referring to the comparatively short interspaces.

Holotype. – SMNH No. X 1009, Fig. 66A.

Type strata. – Upper Visby Beds (sample G 72-7 KL).

Type locality. – Gnisvärd 1, Gotland.

Material. – From the type locality 20 specimens, from other localities in the Upper Visby Beds 75 specimens, and 33 specimens from the Högklint Beds.

Diagnosis. – Small *Gotlandellites* gently increasing in diameter towards distal end, proximal growth angle 4–5.5°. Rings alike, increasing gradually in size and spacing distally. Rings slightly asymmetrical or symmetrical with rounded crests. Interspaces flat to concave, approximately the same width as bases of rings. Annulets in each interspaces few, with low relief. Lirae unknown. Proximal septal region; septa few, free or endoconic. Internal wall surface of living chamber smooth proximally, smooth or slightly undulating distally.

Description. – Conch with distinct curvature, expanding in proximal part at 4–5.5°, distally slightly less. Diameter increasing gently from 0.10 mm at proximal end to 0.85 mm at distal end. Maximum length observed 4.7 mm, full estimated at 5.0–5.5 mm, no intial chamber found. Aperture slightly oblique to long axis.

Rings alike increasing gradually in size and spacing distally. Density of rings 14–16 per mm proximally, 8–10 per mm distally. Rings slightly oblique to long axis, sloping 1–2° towards convex side of conch, symmetrical or slightly asymmetrical and prosocline, crests rounded. Height: basal width 1: 1.0–1.5. Annulets weakly developed, orthocline and low, 2 or 3 per interspace. Interspaces flat or slightly concave, 0.9–1.0 of width of base of rings.

Lirae not proved in material available. The few specimens examined by SEM have short, longitudinal striae on distal slopes of rings (Fig. 66C), but the nature of these striae, whether artificially produced or not, cannot be established.

Proximal septal regions; free septa, total uncertain because material is much fragmented. A few specimens with distal septa forming endocones along length of 0.9 mm. Last septum at conch diameter of 0.20–0.26 mm. Free parts of septa straight, generally perpendicular to long axis, very thin, 0.01 mm. Mural parts very long, that most distal extending 1.5 mm along living chamber.

Living chamber symmetrical with conical proximal end. Internal wall surface smooth proximally, slightly irregular distally.

Thickness of primary shell 0.01–0.015 mm proximally, 0.025–0.03 mm distally. Total thickness of proximal wall doubled by mural parts. No pseudopuncta.

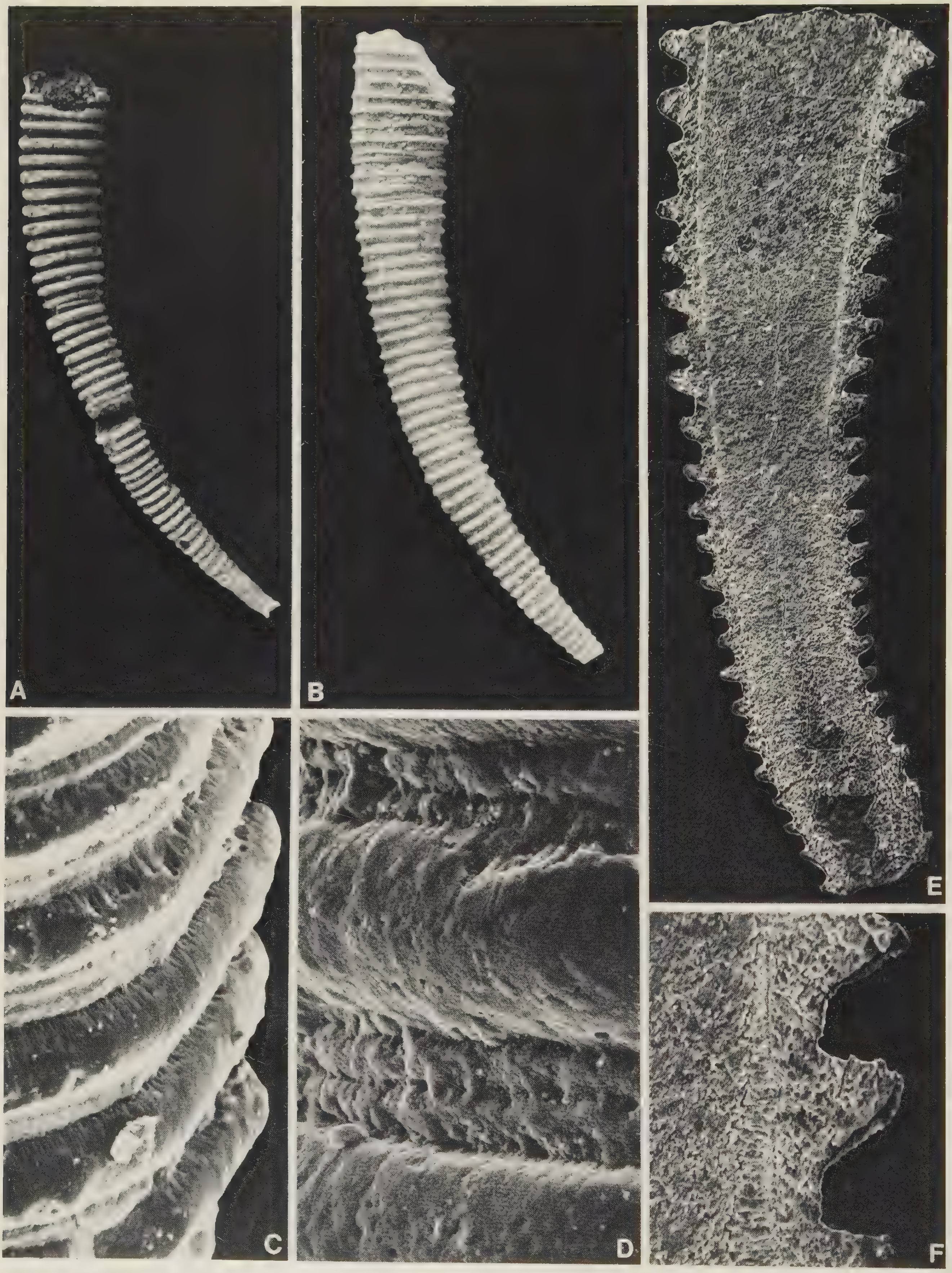


Fig. 66. Gotlandellites areolatus n. sp. ☐ A. Holotype, SMNH X 1009, ×25; Gnisvärd 1, G 72-7 KL. ☐ B. SMNH X 1010, ×25; Gutevägen 1, MS 451. ☐ C, D. Oblique apertural view of rings, ×300, and detail of rings and annulets, ×600, SMNH X 1012; Ygne 2, G 72-2 KL. ☐ E, F. Longitudinal section of wall, ×100, and detail, ×300, SMNH X 1011; Gnisvärd 1, MS 37.

Table 44. Gotlandellites areolatus n. sp. (dimensions in mm).

Spec. No.	DEEC	DDPE	ODID	OPRD	ODLS	TNRI	PA
SMNH X 1009 (holotype)	4.00		0.61	0.13		45	5°
SMNH X 1010	4.67	1.68	0.70	0.19		51	5.5°
SMNH X 1011	1.68	0.35	0.40	0.19	0.26	23	
SMNH X 1013	2.63	0.46	0.68	0.30		28	

Remarks. – Some variation occurs in the spacing of the proximal rings. There may be some differences in the shape of rings, especially in the Högklint specimens which tend to have less rounded crests. There is some variation in the development of septa, which may either have straight free parts and be well spaced, or be tightly stacked endocones. The material sectioned is still insufficient to establish whether there is any preference in the type of septal arrangement.

The material was difficult to clean properly, and thus study of the surface microstructures was difficult. The presence of lirae could not be established. One specimen showed longitudinal striae on the lower distal slopes of the rings (Fig. 66C); whether these structures are significant for the species cannot yet be established.

The characters differentiating *Gotlandellites areolatus* from *G. visbyensis* are discussed in the description of the latter.

Occurrence. – *Gotlandellites areolatus* is the dominant tentaculitid in the Upper Visby Beds. It appears close to the base of the unit at Vattenfallet 1 where it extends up through units *a* and *b* of the Högklint Beds. There, its highest stratigraphical level is 19.85 m above sea level, i.e. 9.85 m above the Upper Visby–Högklint boundary. It has not been found outside Gotland.

Gotlandellites visbyensis n. sp.

Fig. 67.

Derivation of name. – Latin *Visbyensis,* inhabitant of Visby, referring to the Visby area and the Lower Visby Beds.

Holotype. – SMNH No. X 1001, Fig. 67A.

Type strata. – Lower Visby Beds (sample G 72-8 KL).

Type locality. – Nyhamn 1, Gotland.

Material. – From the type locality more than 400 specimens, from additional localities more than 500 specimens.

Diagnosis. – Small, *Gotlandellites,* increasing gently in width towards distal end, with a proximal growth angle of 5–7°. Rings alike, increasing gradually in spacing and size distally, symmetrical with subtriangular profile. Interspaces slightly concave, 1.5–2 times as wide as bases of rings, distally with 7–9 annulets. Proximal septal region; septa with oblique free parts and very long mural parts. Internal wall surface smooth proximally, slightly irregular distally.

Description. – Curvature of conch distinct, proximal part expanding at 5–7°, distal part at 3–4°. Small-sized, not exceeding 3.5 mm in material available, estimated adult length 4–4.5 mm, no initial chamber found. Diameter of conch increasing gently from ca. 0.07 mm proximally to 0.07 mm distally, aperture slightly oblique to long axis.

Rings alike, increasing gradually in size spacing distally, slightly oblique to long axis, annular slope towards convex side 1–2°. Density of rings 11–15 per mm proximally, 7–10 per mm distally (measured at conch diameter less than 0.2 mm and more than 0.45 mm, respectively). Rings symmetrical, with gently rounded crests and flat slopes. Height: basal width 1: 1. Annulets regularly spaced in interspaces, 3–5 per interspace proximally, 7–9 distally, orthocline and pointed. Interspaces flat or slightly concave, 1.5–2 times as wide as bases of rings. Lirae weakly developed, distal on slopes of rings, with a distal density of ca. 30 per 0.1 mm.

Proximal septal region; septa closely spaced, 0.05–0.07 mm apart, more than 20, last septum at outer conch diameter of 0.25–0.30 mm. Septa normally sloping slightly (1–2°) towards convex side of conch. Free parts straight or slightly convex. Mural parts very persistent, the last up to 1.25 mm long, i.e. 2/3 the length of living chamber. Examination of septa in polarized light shows texture to differ from that of primary shell.

Living chamber symmetrical, slightly conical with blunt proximal end. Internal wall surface smooth proximally, slightly irregular distally.

Thickness of primary shell 0.01–0.015 mm proximally, 0.03–0.045 mm distally. Secondary thickening from mural parts almost doubling wall thickness, with maximum at last septum where thickness of primary shell 0.015 mm and thickness of secondary shell 0.025 mm. No pseudopuncta.

Remarks. – The external features of *Gotlandellites visbyensis* show little variation in the many populations studied. Some minor irregularities have been observed in the spacing of the proximal rings; occasionally, some pairing of rings occurs in this part. Some variation may be observed in the attitude of septa, which may have steeply inclined free parts towards the convex side of the conch (Fig. 67D). In the specimen figured the septa are developed on only one side, but this probably results from preparation of thin sections.

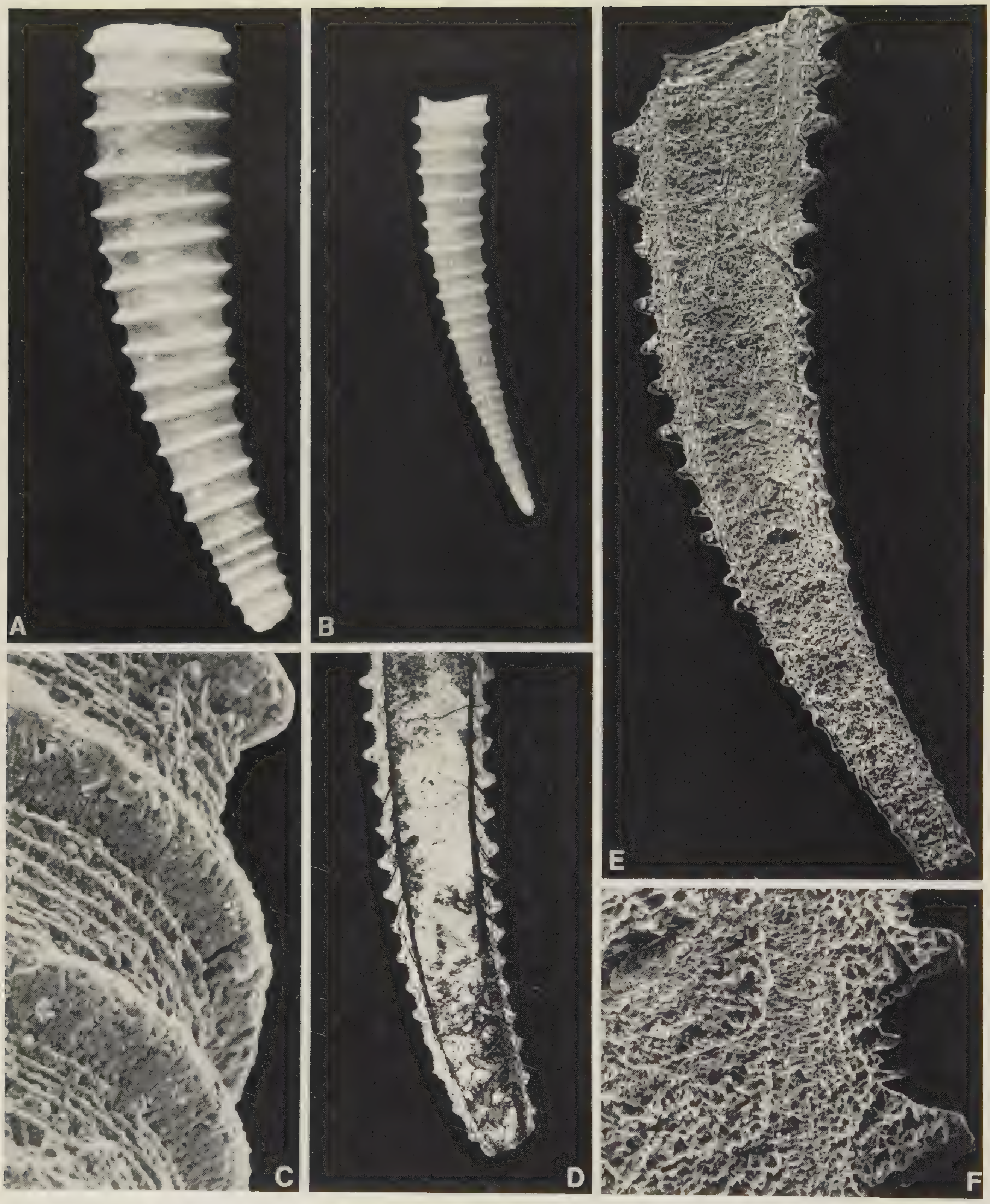


Fig. 67. Gotlandellites visbyensis n. sp. A, D. Nyhamn 1, G 72-8 KL. B. Nyhamn 1, MS 485. C. Nyhamn 1, MS 875. E, F. Nyhamn 1, G 74-57 KL. ☐ A. Holotype, SMNH X 1001, ×50. ☐ B. Specimen showing juvenile part of conch, SMNH X 1003, ×50. ☐ C. Oblique adapertural view of rings and annulets, SMNH X 1687, ×300. ☐ D. Longitudinal section of septal region (polarized light), SMNH X 1005, ×50. ☐ E, F. Longitudinal section of septa, ×100, and detail, ×400, SMNH X 1004.

Gotlandellites visbyensis is very similar to the other *Gotlandellites* species, *G. areolatus,* in general shape and size, but it may be easily distinguished by the triangular profile of its rings, the wider interspaces, the pointed annulets and larger number of annulets per interspace. *G. visbyensis* also resembles an undescribed *Gotlandellites* species occurring in the Purple Shales of Shropshire, Great Britain, but differs from the latter by the lower relief of its rings.

Table 45. Gotlandellites visbyensis n. sp. (dimensions in mm).

Spec. No.	DEEC	DDPE	ODID	OPRD	ODLS	TNRI	PA
SMNH X 1001 (holotype)	2.13	0.42	0.45	0.18		19	
SMNH X 1002	2.68	0.53	0.53	0.28		22	
SMNH X 1003	1.50	0.25	0.23	0.04		23	5.5°
SMNH X 1004	1.45	0.55	0.28	0.09	0.28	24	7°
SMNH X 1005	2.80	0.20	0.45	0.20	0.30	26	
SMNH X 1006	2.17	0.80	0.35	0.08	0.31	28	6.5°

Occurrence. – *Gotlandellites visbyensis* is the dominant in the Lower Visby Beds, in which it ranges to the uppermost part. Because the boundary of the Lower and Upper Visby Beds is difficult to distinguish lithologically at the various localities, the upper stratigraphical limit of the species cannot yet be settled. In all samples from the boundary interval, it occurs together with *Porpites porpita,* which has been generally regarded as an index fossil for the Lower Visby Beds. The stratigraphical value of the latter has recently (Sheehan 1977) been qeustioned because it appears to extend into Upper Visby Beds at Snäckgärdsbaden 1. However, these occurrences are referred to *Porpites* cf. *porpita,* and it could be another undescribed species of *Porpites.* Finds of a *Porpites* species is basal Wenlock strata (M. G. Bassett, personal communication) might support such an interpretation. Lower in the sequence, fragments possibly of *G. visbyensis* have been found in the core of the borehole Visbyborrningen 1 at 60.90–61.54 m and 106–107 m. The age of these levels can be placed at C_5 (M. G. Bassett, personal communication 1976). Outside Gotland, *Gotlandellites visbyensis,* or a closely related species has so far been seen only in the Purple Shales of Shropshire, Great Britain.

Biostratigraphical significance

This study shows that Silurian thick-walled tentaculitoids are useful for biostratigraphy, as is the case with Devonian tentaculitoids, both thin- and thick-walled. Within the two areas investigated, Gotland and Scania, it is obvious that the various horizons are characterized by significant populations of tentaculitids. The taxa are well-differentiated and possess the qualities of index fossils, i.e. rapid evolution, wide geographical distribution, tolerance of many environments, abundance. Morphological characters allow simple identification of taxa. The qualities are comparable with those of other important fossil groups, i.e. palaeocope ostracodes, chitinozoans and conodonts. It is pleasing to conclude that Hadding's (1933: 10) prediction for tentaculitids that "they ought to be valuable as index fossils" has come true.

It is evident from the range charts, Figs. 68 and 69, that the specific ranges are short, in several cases confined within a graptolite zone or an ostracode or conodont fauna. The vertical distribution of tentaculitids, both on Gotland and in Scania, shows clearly that the ranges of well defined faunas fall within the established topostratigraphical units. Thus, on Gotland at least, tentaculitids are another fossil group which corroborates broadly Hede's (1921) topostratigraphical division of the sequence.

The study shows that the diversity and vertical distribution of Silurian tentaculitids differ from earlier concepts, not only on Gotland and in Scania. Thus, care is necessary with older notes on distribution and occurrence of tentaculitids in the Silurian. For example, *Tentaculites hisingeri* has been referred to commonly in literature as *T. scalaris* and reported from the Burgsvik and Hamra Beds on Gotland, and from the Öved-Ramsåsa Beds units *1–2* in Scania. It can now be demonstrated that *Tentaculites scalaris* is confined to the units *3–4* of the Öved-Ramsåsa Beds, while *T. hisingeri* is a closely related species which precedes it stratigraphically. Another species reported commonly from the Ludlow of Gotland is *Lonchidium inaequalae.* However, this species is confined to levels well up in the Downtonian and does not occur in Sweden. The Ludlovian tentaculitids earlier referred to *L. inaequalae* include at least four new species of *Lonchidium.*

The regional distribution of tentaculitids can so far only be considered for one basin. Correlation between Gotland and Scania by means of tentaculitid faunas is good, although there are also some very different faunal elements in the two areas. The horizontal distribution outside Sweden of the taxa described is still poorly known. This reflects basically the lack of modern studies on Silurian tentaculitids from other areas. Some of the Downtonian species in Scania can be proved to occur in Estonia and Poland. This seems further evidence that thick-walled tentaculitoids may be used for intra-basinal comparison. Correlation using tentaculitids is less fruitful with other areas, especially with Great Britain where only one tentaculitid species occurring in Sweden has so far been identified. However, it should be stressed that my comparison is limited to a few horizons in the British Silurian, i.e. with some museum material from Dudley, Shropshire and Usk. The upper Wenlockian sequence at Dudley yields three or four species but none of these occur in Sweden. From Shropshire there is only one species in common with Gotland, from the uppermost Llandoverian. The lack of good correlation with the sequence in Great Britain may relate largely to the

Silurian tentaculitid faunas there being almost unknown; the few species from Britian described in the previous literature badly need revision. The same is true of the Silurian faunas of Norway, which have never been described although some species have been named and also illustrated (e.g. in Kiaer 1908). From areas outside Europe, what illustrated material there is of Silurian tentaculitids reveals no similarities to the faunas described in this paper. Again, the vertical and horizontal distribution of the faunas of the other areas are practically unknown. All species which have been described and figured need thorough revision. Most descriptions of tentaculitid species from North and South America, Australia and Asia are in papers published in the second half of the nineteenth century.

The occurrence of tentaculitids in many sedimentary environments on Gotland and in Scania demonstrates well the tolerance to different facies of the various species. There are certainly differences in abundance among environments. The overall environment characterizing the areas is a shallow epicontinental sea. Within this major facies realm, tentaculitids are as biostratigraphically important as other groups of index fossils, e.g. palaeocope ostracodes.

Tentaculitids are abundant in most of the horizons and localities sampled. Thus, from a sample of moderate size, one may expect many identifiable conchs to indicate the age of the sample horizon, generally sufficient for correlation. This applies also to core material, as is evident from the boreholes examined for this study.

The various morphological elements of the conchs are in most cases well defined. Commonly, small fragments of the conch are sufficient for firm identification without need for elaborate preparation techniques. I hope that the illustrations and descriptions given in this paper will enable easy identification.

From the distributional pattern of the tentaculitids on Gotland and in Scania, it is possible to establish a zonal scheme for this region. However, such a scheme is not given here because I feel it necessary first to examine in more detail Silurian tentaculitid faunas from other parts of the Baltic basin, e.g. Estonia, Northern Poland and Norway. Our knowledge of the Llandoverian and Downtonian-Podlasian faunas still has big gaps, which it may be possible to fill when the faunas of the areas mentioned are examined. Then, a zonal scheme for the whole Silurian could be established; only a scheme based on tentaculitids from the upper Llandoverian – lower Downtonian could be formed now.

Stratigraphical distribution and correlation

To supplement discussion of the distribution of tentaculitid faunas in the stratigraphical units of Gotland and Scania, the ranges of all species described, arranged stratigraphically, are shown (Figs. 68 and 69). Occurrences are plotted as black squares. Open squares denote that specimens could not be firmly identified.

It should be stressed that the mutal relationship of units on Gotland is simplified in Fig. 68. It is evident from recent studies (e.g. Martinsson 1967, Laufeld 1974b, Laufeld & Jeppsson 1976) that several units are lateral equivalents and are strongly diachronous, particularly upper Wenlockian – lower Ludlovian sequences. For convenience, the stratigraphical sub-units are arranged according to the scheme presented by Laufeld (1974b, Fig. 77). The distribution of tentaculitid species in the units and temporal relationships will be discussed more thoroughly in the text.

Distribution is discussed first for Gotland then for Scania. It is unavoidable that the faunal development in Scania will be described during the account for Gotland when correlation of the two areas is discussed.

Lower Visby Beds. – The lowest supramarine unit of Gotland yielded two tentaculitid species belonging to two genera, i.e. *Gotlandellites visbyensis* and *Seretites? exilis.* The former species, in the supramarine sequence, is restricted to the Lower Visby Beds. It is the more abundant of the two species. It ranges up to the top of the unit. However, its exact upper limit with reference to the boundary of the Lower and Upper Visby Beds is still uncertain because this level is difficult to locate without detailed exmination of the fossil fauna across the boundary. The earliest occurrence of tentaculitids on Gotland is in the core of borehole Visbyborrningen 1 at a depth of 106–107 m where there are a few fragments, probably of *G. visbyensis.* Similar fragments have also been obtained from the same core at 60.90–61.54 m. It is not certain whether these beds should be regarded as Lower Visby Beds because lower boundary of the unit has not yet been delimited. However, the levels in question are clearly of C_5 (Telychian) age (M. G. Bassett, personal communication 1976).

The tentaculitid fauna of the Lower Visby Beds correlates well with that, still undescribed, from the Purple Shale in Shropshire, Great Britain. In samples obtained from Dr. A. Aldridge, Nottingham University, abundant specimens of *Gotlandellites* have been identified, some closely related to or identical with *G. visbyensis.* Some minute fragments suggest the presence also of a *Seretites?* species in these samples. The stratigraphical ranges of these tentaculitids within the Purple Shale have not so far been established.

Upper Visby Beds. – Three species, *Gotlandellites areolatus, Seretites? exilis* and *S.? cataractae,* occur concurrently in the Upper Visby Beds. None of these species are exclusive to these strata. *Gotlandellites areolatus* appears little above the lower limit of the unit, as at Vattenfallsprofilen 1 and like *Seretites? cataractae* passes the Upper Visby – Högklint Beds boundary. The latter species appears for the first time on Gotland a few metres below this boundary. *S.? exilis* only passes the boundary between the Lower and Upper Visby Beds. At all localities studied which expose strata of Upper Visby Beds age, *Gotlandellites areolatus* is by far the dominant tentaculitid species.

Högklint Beds. – Two of the three species in the Upper Visby Beds continue into the Högklint Beds where three

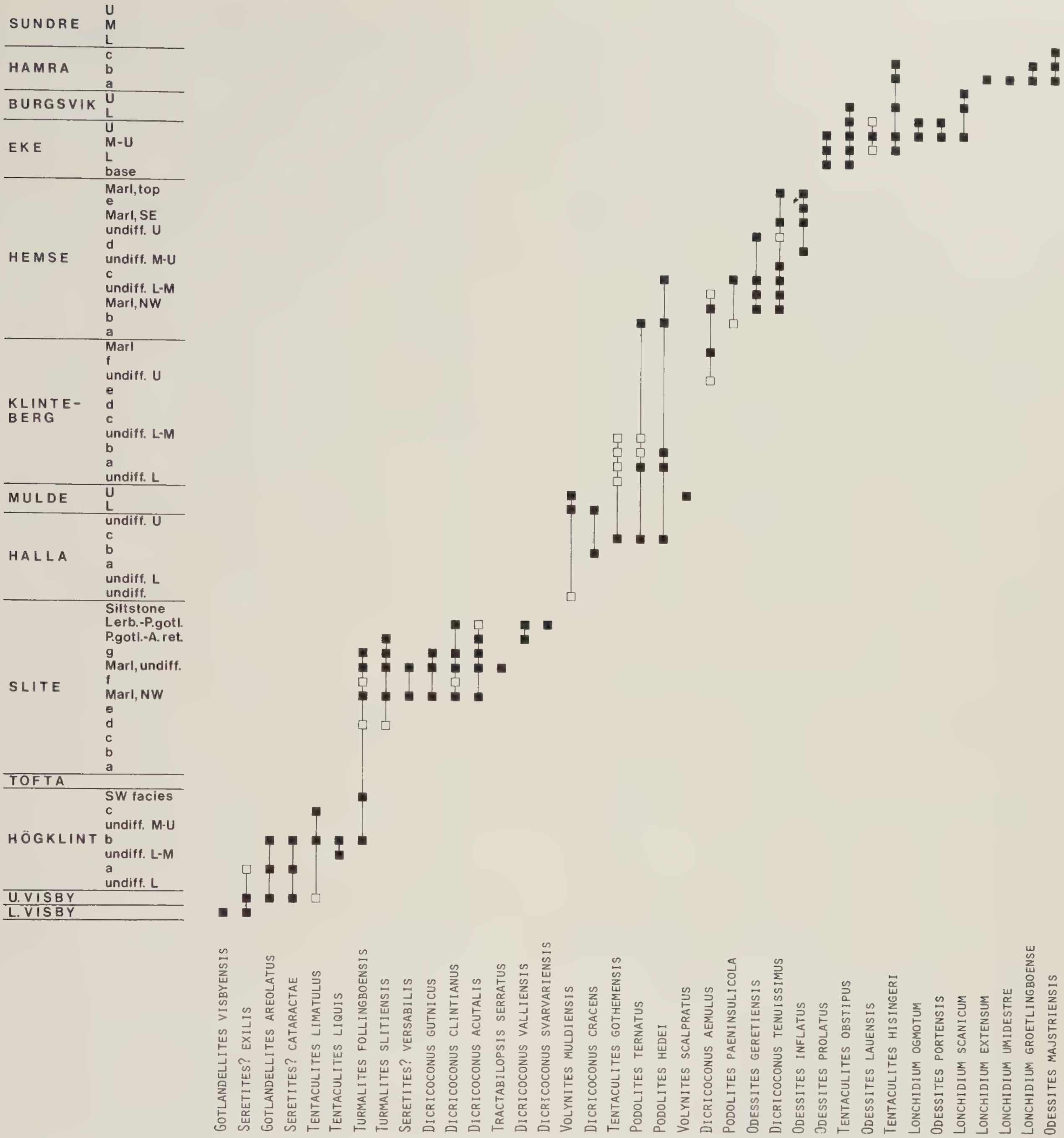


Fig. 68. Stratigraphical ranges of Silurian tentaculitids of Gotland. Filled squares represent typical populations, while open squares represent either forms referred to as cf. or those not specifically determined. Stratigraphic subdivision in accordance with Laufeld 1974b, Fig. 77.

new species, *Tentaculites limatulus, T. liquis,* and *Turmalites follingboensis,* appear. Of the three new species, the last-mentioned continues up into the Slite Beds, while *T. limatulus* and *T. liquis* are confined to the middle and upper Högklint Beds. Detailed examination of faunal and floral dynamics in the lower Wenlock sequence at Vattenfallsprofilen 1 has delimited the distribution of some of the species. *Gotlandellites areolatus* occurs abundantly up to the middle part of unit *b,* as does *Seretites? cataractae* which almost reaches the top of the unit. *Tentaculites limatulus* is restricted to units *b* and *c* although it is possible that it occurs both earlier and later, as is indicated by one fragment found one metre below the Upper Visby – Högklint Beds boundary and two moulds in unit *d* of the Högklint Beds in the section at Vattenfallsprofilen 1. However, the identity of these fragments is not definite and they are designated provisionally as *Tentaculites* cf. *limatulus. Tentaculites limatulus* is not very common and it has so far been found only at a few localities in northwesternmost Gotland. The closely related *T. liquis* is the characteristic species in unit *b* at localities around Kappelshamn Bay and on Fårö Island in northern Gotland. It is restricted to this unit. Although numerous samples have been examined from the corresponding level in the section at Vattenfallsprofilen 1, no specimen of this species has been found. *Turmalites follingboensis* occurs sparsely at a few localities exposing unit *b* (Horsan 1, Släthällar 2) and in the southwest facies of the Högklint Beds at Ansarve 1–3. The infrequency of tentaculitids in the latter area is striking. It is possible that conditions were deeper there, as is indicated by the lack of reefs and the more argillaceous nature of the sediments, and were less favourable to the development of prolific tentaculitid faunas.

The distribution of tentaculitids in the Högklint Beds indicates that not many species can be used for further subdivision of the unit. The spatial distribution of some species, e.g. *Tentaculites limatulus* and *T. liquis,* is very irregular. This is unfortunate considering their rather limited temporal distribution.

Tofta Beds. – In spite of extensive sampling in the Tofta Beds no tentaculitids were found during the present study. This can probably be ascribed to unfavourable environmental factors, such as extremely shallow-water conditions with evidence of erosional events (Hede 1940: 43) and bottom and wave conditions favouring the development of oncolitic algae (cf. Hede 1940, Fig. 13). In other strata with prolific growth of algae tentaculitids occur very rarely (e.g. Klinteberg Beds, Hamra Beds, unit *a*).

In the literature, only one occurrence of a tentaculitid in the Tofta Beds has been reported, i.e. Hede (1921: 37) recorded an *Alternatus?* species as *Tentaculites multiannulatus.* It is significant that this genus was found, because other occurrences of species of *Alternatus?* indicate greater tolerance than other tentaculitid genera towards hostile environments.

Only one species, *Turmalites follingboensis,* which occurs in beds older than the Tofta Beds, also occurs in younger beds.

Slite Beds. – The lower units, *a* to *e,* of the Slite Beds give a very poor yield of tentaculitids, probably because of unfavourable bottom conditions. Most of the five units comprise coarse calcarenites, occasionally with some mud. Only one locality, Stora Myre 1 in unit *d,* has yielded a few fragments which could be provisionally referred to *Turmalites follingboensis?* and *Turmalites slitiensis?*. Otherwise only some poorly preserved specimens of *Alternatus?* species have been found.

Passing from the limestone belt in the west to the wide eastern tract which chiefly comprises marly deposits, quite another picture emerges with a radical change in abundance and diversity of the tentaculitid fauna. In the Slite Marl, northwestern part, four new species appear, five if some still undifferentiated levels in the Slite Marl are included. In most samples an abundant fauna with *Turmalites follingboensis, Turmalites slitiensis, Dicricoconus acutalis, D. gutnicus* and *Seretites? versabilis* occurs. *Dicricoconus clintianus* is sparse in the Slite Marl, northwestern part, units *f* and *g* and in undifferentiated levels within the Slite Marl. Only two of these species, *T. follingboensis* and *D. clintianus,* seem to occur in the *Conchidium tenuistriatum* Beds. However, the material is poorly preserved. All species except *Seretites? versabilis* pass into the Ryssnäs Limestone, unit *g.* A few, *Turmalites slitiensis, D. acutalis* and particularly *D. clintianus,* also appear in the *Pentamerus gotlandicus* Beds although the first two species occur only sparsely. The vertical distribution of *Seretites? versabilis* is very limited, and is even narrower in *Tractabilopsis serratus* which occurs immediately below the Ryssnäs Limestone in a restricted area on the east coast of Fårö Island from Sudersandsviken 1 to Haganäs 1. In that area it forms the dominant species, e.g., at Haganäs 1.

There is generally no problem correlating levels in the Slite Marl using tentaculitids. Only in the southwestern area, e.g., in the area around Valbytte 1 and 2, the low abundance of tentaculitids may cause some problems. The low abundance can probably be ascribed to deeper conditions.

In the upper Slite Marl in the southwestern area around Klintehamn, a completely new association of tentaculitids appears. The beds, referred to as *Pentamerus gotlandicus* Beds (Hede 1927a: 29–30), lie immediately below the top unit of the Slite Beds, the Slite Siltstone, and contain three species of *Dicricoconus,* i.e. *D. clintianus, D. svarvariensis,* and *D. valliensis.* The last species also occurs in *Pentamerus gotlandicus* Beds more to the northeast, in the Vallstena – Tjeldersholm area. *Dicricoconus clintianus* is very common at all localities in the Klintehamn area.

The Slite Siltstone has not yielded tentaculitids. In the stratigraphical scheme of Laufeld & Jeppsson (1976, Fig. 4), this unit is shown as laterally equivalent in northwest Gotland to unit *g* and to the underlying Slite Marl, in southwest Gotland also to the topmost Slite Marl. This synchroneity of the *Pentamerus gotlandicus* Beds and unit *g* has some confirmation in the occurrence in both units of *Dicricoconus clintianus.* However, there are also major differences: *Turmalites follingboensis* and *Dicricoconus gutnicus* are missing in the *P. gotlandicus* Beds in both the southwest and northeast. There is good reason to believe that the *Dicricoconus* fauna of the southwest is younger than the Ryssnäs Limestone fauna of the northeast. The latter unit was considered a member of unit *b* by Laufeld (1974b: 10). Beds above the *P. gotlandicus* Beds have none of the species just mentioned. Next to the Slite – Mulde and Hemse – Eke boundaries, the Slite – Halla boundary shows the most conspicuous change of the tentaculitid fauna on Gotland.

Halla Beds. – In the Halla Beds the earliest tentaculitids come from unit *b* at Hörsne 1, where sparse specimens of *Dicricoconus cracens* occur together with a very prolific fauna of *Alternatus?* spp. This level is obviously in the middle or upper part of unit *b* because *Dicricoconus cracens* found in the southwest in lowermost unit *b,* which there rests unconformably on the Slite Siltstone, e.g. Klintebys 1. The occurrence of *Dicricoconus cracens* in unit *b* is notable because the species is otherwise restricted to the lower Mulde Beds. Thus, this species corroborates the correlation of the Mulde Beds with the lower Halla Beds as is outlined in Martinsson (1967: 365). The stratigraphical scheme of Laufeld & Jeppsson (1976, Fig. 4) shows the same correlation, but unfortunately it is not commented on in the text and so the criteria for such correlation are uncertain.

Another species which shows affinity to Mulde Beds fauna, and here referred to as *Volynites* cf. *muldiensis*, has been found sparsely at one Halla Beds locality, i.e. Gandarve 1. The exact level within the Halla Beds of this locality is not known (Hede 1929: 16) but, judging from the occurrence of *Volynites muldiensis* mainly in the upper Mulde Beds, a level high in unit *b* or low in *c* is possible.

The Halla Beds unit *c*, has a completely new fauna. The genus *Podolites* appears on Gotland for the first time. Two species are represented together with *Tentaculites gothemensis*. This fauna is encountered chiefly at localities in the Gothemshammar area. At several places there and also in the Hörsne area, the three species continue into the lower Klinteberg Beds. For *Tentaculites gothemensis* it is not fully certain, but *Podolites hedei* and *P. ternatus* go on up into the Hemse Beds. *Podolites ternatus* and, particularly, *P. hedei* occur very abundantly in unit *c* of the Halla Beds. None of the three species have been found in the Mulde Beds, although at least their uppermost part should be equivalent to lower and middle unit *c* of the Halla Beds according to Laufeld & Jeppsson (1976, Fig. 4). Instead, *Tentaculites gothemensis?* and *Podolites hedei?* have been found at several localities in the lower Klinteberg Beds of the southwest, the former species e.g. at Forse 1 and Klinteberget 1, the latter at Fröjel 4 and Klinteberget 1. Unfortunately the preservation in generally calcarenitic beds is poor, and this makes difficult precise identification of species. However, the generic designation is indisputable. The occurrence of similar tentaculitid faunas in the upper Halla Beds in the northeast and the lower Klinteberg Beds in the southwest points to diachronism of these units on Gotland, as was shown by Martinsson (1967, Fig. 2) and Laufeld & Jeppsson (1976, Fig. 4).

Mulde Beds. – The Mulde Beds have a well defined tentaculitid fauna and the two established units are clearly distinguished on occurrence of easily recognized species. The lower part is characterized by *Dicricoconus cracens*, while *Volynites muldiensis* is by far the dominant species, together with *Volynites scalpratus*, in the upper Mulde Beds. The most abundant occurrences of *Volynites muldiensis* were at Mulde Tegelbruk 1 and Klintebys 1. Both localities were referred by Laufeld (1974a) to undifferentiated Mulde Beds but, judging from the occurrence of this species at othe localities in upper Mulde Beds, the two localities should also be high in the sequence. This is further supported by the fact that samples from localities with lower Mulde Beds, e.g. Blåhäll 1 and Djupvik 1, do not contain *Volynites muldiensis* except one specimen at Djupvik 1. The third Mulde Beds species, *Volynites scalpratus*, has so far only been found at Mulde Tegelbruk 1.

The tentaculitid faunas of the Mulde Beds have nothing in common with those either of the underlying Slite Siltstone and its equivalents or of the overlying Klinteberg Beds. The distinct faunal break at the Slite – Mulde boundary conforms to that observed for other fossil groups, as was described by Hede (1921: 50–51). However, it is not true of the chitinozoans which, according to Laufeld (1974b: 127), have a "Slite aspect". There are no faunal elements in common for the upper Mulde Beds and the upper Halla Beds (unit *c*), although equivalence of these levels is indicated in Laufeld & Jeppsson (1976, Fig. 4). The correlation favoured by Martinsson (1967: 365, Fig. 2) of the upper Mulde Beds with the lower-middle Halla Beds seems more appropriate to the distribution of the tentaculitid faunas.

Klinteberg Beds. – The distribution of tentaculitids in the lower Klinteberg Beds has been discussed in the preceding sections. Not much is known about the distribution of tentaculitids in the middle and upper Klinteberg Beds, mainly because of the unfavourable facies in which limestones and reefs predominate. However, it is evident that *Podolites hedei* and *P. ternatus* continue into the lower Hemse Beds. In the southern area of Klinteberg Beds, north of Hemse, Laufeld (1974b: 11) distinguished Klinteberg Marl forming the top Klinteberg Beds. This unit contains a very characteristic species, *Dicriconus aemulus*, which also appears in the Hemse Marl, northwestern part.

Hemse Beds. – The earliest tentaculitid in the Hemse Beds seems to be *Dicricoconus aemulus*, which appears low in the Hemse Marl, northwestern part, at Snoder 1–2, Eske 1 and in the area of Lilla Hallvards. In the last area, it does not occur at localities Lilla Hallvards 1–4. The specimen (Fig. 59A) derives from Hede's collection and was probably sampled somewhat northwest of the classic Lilla Hallvards (Petesvik) locality.

The absence at Snoder 1–2 and Eske 1 of another significant *Dicricoconus* species which appears higher in the Hemse Marl, i.e. *D. tenuissimus*, may indicate that the localities are rather low in the Hemse Marl. *Dicricoconus aemulus* only appears at localities within the Hemse Marl, northwestern part. Its northeasternmost occurrence is at Tänglings 1, and it has not been identified in levels referred to unit *a* of the Hemse Beds. Diachronism of the Klinteberg – Hemse boundary seems well demonstrated by this species.

A common species in the Hemse Beds is *Dicricoconus tenuissimus* (Hede). It appears in the Hemse Marl, northwestern part, and ranges into the upper part of unit *e* in the northeast. It probably does not reach the level with *Dayia navicula* (*Dayia* Flags) on Gotland; it is missing from all localities where these beds are exposed, e.g., at Botvide 1, Gogs 1, Nyan 2, Malms 1. A similar range is indicated from the borehole Burgsviksborrningen 1 where the highest record of the species is 71.13 m, i.e. 7.63 m below the Hemse – Eke boundary. In Scania *D. tenuissimus* has not been found in the *Dayia* Flags at the bottom of the Öved-Ramsåsa Beds either.

The earliest occurrence of *Dicricoconus tenuissimus* seems to be at Lukse 1. It forms the main constituent of the tentaculitid fauna in the southwesternmost area with Hemse Beds, i.e. along the coast from Lilla Hallvards 1 to Vaktård 1–2. It is also characteristic of the southeastern Hemse Marl.

Another interesting tentaculitid species is *Odessites geretiensis*. It enters the sequence together with *D. tenuissimus* but does not range up to the levels of the coastal localities mentioned above. Instead, its main distribution is at e.g. Gerete 1, Rangsarve 1, Amlings 1, Tänglings 1 and Sigvalde 1. It has also been found in the northeasternmost Hemse Beds at Hammarudden 1 and Grogarnshuvud 1, i.e. in unit *c* of the Hemse Beds.

With the appearance on Gotland of *Dicricoconus tenuissimus* and *Odessites geretiensis,* we can for the first time correlate with tentaculitid faunas in Scania. There, both species occur at Skarhult in the middle of the *Colonus* Beds and the former species has also been found at Röddinge 1, in beds approximately equivalent in age. This same correlation has been demonstrated previously by graptolites.

In the limestone area in the Östergarn district of Gotland, the lowest Hemse Beds tentaculitids are in unit *b.* Faunas are rather sparse with *Podolites hedei* and *P. ternatus.* The former species occurs also in undifferentiated lower-middle Hemse Beds. In unit *c* of the same area, the dominant species is *Podolites paeninsulicola.* It seems restricted to the Östergarn area.

In the middle Hemse Beds a new species of *Odessites, O. inflatus,* makes its debut on Gotland. The species appears in the Hemse Marl, southeastern part, at e.g. Västlaus 1, Kodings 1–4, Hulte 1, Tjängdarve 1, Gläves 1, 3 and 4, and in the northeast in the upper part of unit *d* at Sysne 1 and Sysneudd 1. In unit *e* at many localities in the Lau district it forms the dominant species, together with *Dicricoconus tenuissimus. Odessites inflatus* occurs up to the very top of unit *e* but never crosses the Hemse – Eke Beds boundary. In this area it occurs with *Neobeyrichia lauensis.* The same is the case in Scania, where *O. inflatus* is the earliest tentaculitid species in the Öved-Ramsåsa Beds unit *1a sensu* Grönwall (1897) and occurs together with *N. lauensis* at e.g. Lunnarna 2, Klinta 1 and in the lowermost levels at Bjärsjölagård 1. In the borehole Bjärsjölagårdborrningen 1 *O. inflatus* appears close to the base of the core, at 95.72 m, and extends up to 52.50 m. Neither in this core, nor at the localities mentioned in Scania, have traces of *Dicricoconus tenuissimus* been found. This indicates that the lowest Öved-Ramsåsa Beds are synchronous with the topmost Hemse Beds. The great similarity of the palaeocope ostracode faunas of the *Dayia* Flags in Scania and on Gotland was shown by Martinsson (1967: 371).

The appearance of *Odessites inflatus* is consistently in the Hemse Marl close to the northwestern limit of the southeastern facies. This may constitute further evidence of the marked facies and faunal changes that occur in the middle Hemse Beds, as demonstrated by Hede (1927b: 24), Martinsson (1962: 53–54) and Laufeld (1974b: 127).

The diversity of the tentaculitid fauna in the Hemse Beds is exceeded on Gotland only in the Slite Beds. Seven species are present, not including many *Alternatus?* species.

Eke Beds. – There is a drastic change in the tentaculitid faunas at the Hemse – Eke Beds boundary as defined in the Lau areas. At several localities where the basal Eke Beds are exposed, e.g., Botvide 1, Nyan 2, Malms 1, no tentaculitids occur. This is also evident in the southwest, e.g. Bodudd 2, Olsvenne 4, and Sigsarve 1. It is not until levels of, e.g., Havdhem 1, Hallsarve 1, Lingvide 1 and Hummelbosholm 2, that tentaculitids are first found, then represented by *Odessites prolatus* and *Tentaculites obstipus.* Slightly higher, these species are joined by *Tentaculites hisingeri.* The three species form a very characteristic assemblage in the middle Eke Beds. In the upper Eke Beds four new species appear, though at different times. Close to the Eke – Burgsvik Beds boundary the first two representatives of *Lonchidium* appear, i.e. *Lonchidium ogmotum* and *L. scanicum.* A concurrent species is *Odessites portensis,* which has only been found in a restricted interval around the Eke – Burgsvik Beds boundary. *Tentaculites hisingeri* and *T. obstipus* are associated with this fauna, but *Odessites prolatus* has disappeared. The occurrence of *Odessites lauensis* is notable. It has only been found in the *Rhizophyllum* Limestone at Lau Backar 1, and possibly occurs at Petsarve 1 in undifferentiated middle-upper Eke Beds. At Lau Backar 1 no other tentaculitid species occur, while Petsarve 1 has *Tentaculites obstipus.*

Several of the tentaculitid species in the Eke Beds also occur in Scania, and can be used accordingly for correlation. The association of *Lonchidium scanicum, L. ogmotum, Odessites portensis* and *Tentaculites hisingeri* is significant for the middle-upper part of unit *1* (*sensu* Grönwall 1897) of the Öved-Ramsåsa Beds, i.e. in units *2–3 sensu* Eichstädt (1888) or in unit *1b* of Grönwall (1897). Thus, the levels around the Eke – Burgsvik Beds boundary, as seen e.g. in the Ronehamn area on Gotland, seem to correlate perfectly with this interval of the Öved-Ramsåsa Beds. Jeppsson (1974: 11) reached the same conclusion from his conodont studies. Jeppsson compared his Older *Hindeodella steinhornensis scanica* fauna at Klinta and Bjärsjölagård to the conodont fauna of the middle Eke Beds. The early occurrence of *Tentaculites hisingeri* in Scania supports this correlation but, among other important faunal elements of the middle Eke Beds, *Odessites prolatus* is missing in Scania and *Tentaculites obstipus* has only been found rarely in the uppermost part of unit *1b,* i.e. in unit *3 sensu* Eichstädt (1888).

Burgsvik Beds. – The Burgsvik Beds have two of the earlier species, *Tentaculites hisingeri* and *Lonchidium scanicum.* The lowermost beds are characterized by *Lonchidium ogmotum* and *Odessites portensis,* then these disappear shortly above the Eke – Burgsvik boundary. *Tentaculites obstipus* passes up to the top Burgsvik Beds, but never crosses the Burgsvik – Hamra Beds boundary.

The tentaculitid fauna of the Burgsvik Beds corresponds well to that of the uppermost part of unit *1b* of the Öved-Ramsåsa Beds, particularly the *Tentaculites hisingeri – T. obstipus* association.

Hamra Beds. – The Hamra Beds have two species in common with the preceding Burgsvik Beds and four new species, three of which are confined to the middle part, unit *b. Tentaculites hisingeri* is common in all three subunits. Its highest occurrence is at Barkarveård 1 in unit *c.* The lowest unit, *a,* is characterized by the disappearance of *Lonchidium scanicum.*

The main occurrence of tentaculitids is in unit *b,* particularly in the northeastern area, south of Grötlingboudd, i.e. in the Bankvät area. Three species of *Lonchidium* are present and totally dominate the fauna. *Tentaculites hisingeri* occurs sparsely in the area. Much more abundant faunas which include this species are found in unit *b* in the southwestern Hamra Beds, e.g. at Kättelviken 4–5, Husryggen 3, Hallbjäns 1 and Majstre 1. The beds at these localities are probably somewhat younger than those to the northeast at Bankvät, because no *Lonchidium* species occur and a new species, *Odessites majstriensis,* appears. The latter species is a very characteristic constituent of the fauna of units *b* and *c* of the Hamra Beds in southernmost Gotland. That the localities are high in unit *b* is evident from the proximity of the horizons sampled to unit *c,* commonly only a few metres below the biohermal limestones which constitute its base. In the argillaceous equivalent of the bioherms, *Odessites majstriensis* is the only tentaculitid identified certainly apart from species of *Alternatus?*. There are other tentaculitids, probably referable to *Odessites,* but the poor preservation does not permit closer identification. At Barkarveård 1 some specimens which closely resemble *Lonchidium groetlingboense* occur, unfortunately with poorly preserved conchs. These specimens are provisionally referred to *L.* cf. *groetlingboense.*

The present knowledge of the tentaculitid faunas of the Hamra Beds does not permit correlation with levels in the Öved-Ramsåsa Beds. Only *Tentaculites hisingeri* and *Lonchidium scanicum* are common in the Hamra Beds, but in Scania both species extend up to the yellow sandstone, unit *2* (Grönwall 1897), which is almost barren of fossils.

Sundre Beds. – The distribution of tentaculitids in the Sundre Beds is still unsatisfactorily known, mainly because of unfavourable facies of dense crinoidal and reef limestones. Only one tentaculitid species has been definitely identified, i.e. *Odessites majstriensis,* which passes the Hamra – Sundre Beds boundary at Juves 1, 3 and 4. Because this species has not been recorded from Scania no tentaculitid correlation with Scania can be made.

A notable occurrence of tentaculitids is at Holmhällar on the southern point of Gotland, where a fauna has been obtained from fissure fillings in reef limestones. The fauna is not described here because the material is much fragmented and certain assignment of the various pieces cannot be made. It contains at least three species and it is definitely younger than the fauna referred to above at Juves. Some fragments show similarities to *Odessites lebiensis* and *Lonchidium mobergi,* but firm identification is still not possible. It could be that the fauna has some similarity to the lower Downtonian fauna seen in Scania. The palaeocope ostracode fauna has some lower Downtonian aspect because a very characteristic *Berolinella* species which occurs in the fissure fillings also appears in units *3* and *4* of the Öved-Ramsåsa Beds in Scania. The conodont fauna also has a Downtonian affinity (M. Lindström, personal communication 1978). If the Holmhällar fauna turns out to be younger than any other Sundre Beds fauna, it would certainly open interesting palaeogeographical perspectives. The Holmhällar reefs contain a number of fissure fillings (cf. Manten 1971: 200–205). These fissures merit closer examination to settle the age relationship between the reef and the fissure fillings. Manten (1971: 201) favoured filling contemporaneous with reef growth, but his conclusion was based solely on sedimentological criteria.

In the submarine sequence south of Gotland the Silurian samples collected and partly described by Martinsson (1965b: 331–335 and 1967: 375, Fig. 3) include some tentaculitid remains. Only tentaculitids in one sample from Hoburgs Bank, HBB IV: 2 (Martinsson 1965b: 334, Fig. 4), could be identified as *Tentaculites scalaris* von Schlotheim. This species is associated with abundant specimens of *Nodibeyrichia tuberculata,* and accordingly the level is higher than the youngest Silurian beds of Scania. Unfortunately, the poor preservation of tentaculitids in other material from Hoburgs Bank, i.e. HBB 101 (cf. Martinsson 1967: 375, Fig. 3) and HBB I and II (Martinsson 1965b: 334), does not permit definite identification, so no comparison can be made with the contemporaneous tentaculitid faunas in Scania.

In the preceding account, it was necessary to include some comments on the tentaculitid faunas from Scania and the correlation between Gotland and Scania. Still to be mentioned are some striking discrepancies between the faunas of the two areas, and a large part of the sequence in Scania, i.e. the Downtonian, has no equivalent in the supramarine sequence of Gotland. These points will be considered in the following paragraphs.

Colonus *Beds.* – Only two localities in the *Colonus* Beds have yielded tentaculitid faunas, at levels which are probably equivalent. As already pointed out, both the species present, *Dicricoconus tenuissimus* and *Odessites geretiensis,* facilitate good correlation with the Gotland sequence. Because no other tentaculitid faunas are known in Scania until the lowermost Öved-Ramsåsa Beds, there is a considerable gap in our knowledge of the faunas, perhaps of more than one or two graptolite zones. The chance of finding reliable tentaculitid faunas in the upper *Colonus* Beds is probably small too, because of the generally deep-water character of the sediments.

Öved-Ramsåsa Beds. – The lowermost Öved-Ramsåsa Beds, e.g. at Lunnarna, in the ditch section at Bjärsjölagård 1, and in the borehole Bjärsjölagårdborrningen 1, have a characteristic association of *Odessites inflatus* and *O. petilus.* As is seen in the core of Bjärsjölagårdborrningen 1, the latter species appears slightly later than *Odessites inflatus,* and extends somewhat higher in the sequence. Whether or not this is significant is difficult to assess. The occurrence of both species at Lunnarna and at Bjärsjölagård 1 seems to indicate that their range zones are confined, using the conodont terminology of Jeppsson (1974), to beds with the *Pelekysgnathus dubius* fauna, cf. Fig. 69. *Odessites inflatus* has been found in museum material from the Ramsåsa area at Ramsåsa 13 (Ramsåsa locality K of Moberg & Grönwall 1909). Thus, the position of this locality can be settled as within unit *1* of the Öved-Ramsåsa Beds. In the borehole Bjärsjölagårdborrningen 1 a third species, *Lonchidium incilense,* occurs in the upper part of the range zones of the two species. A different distribution is indicated by the lowest

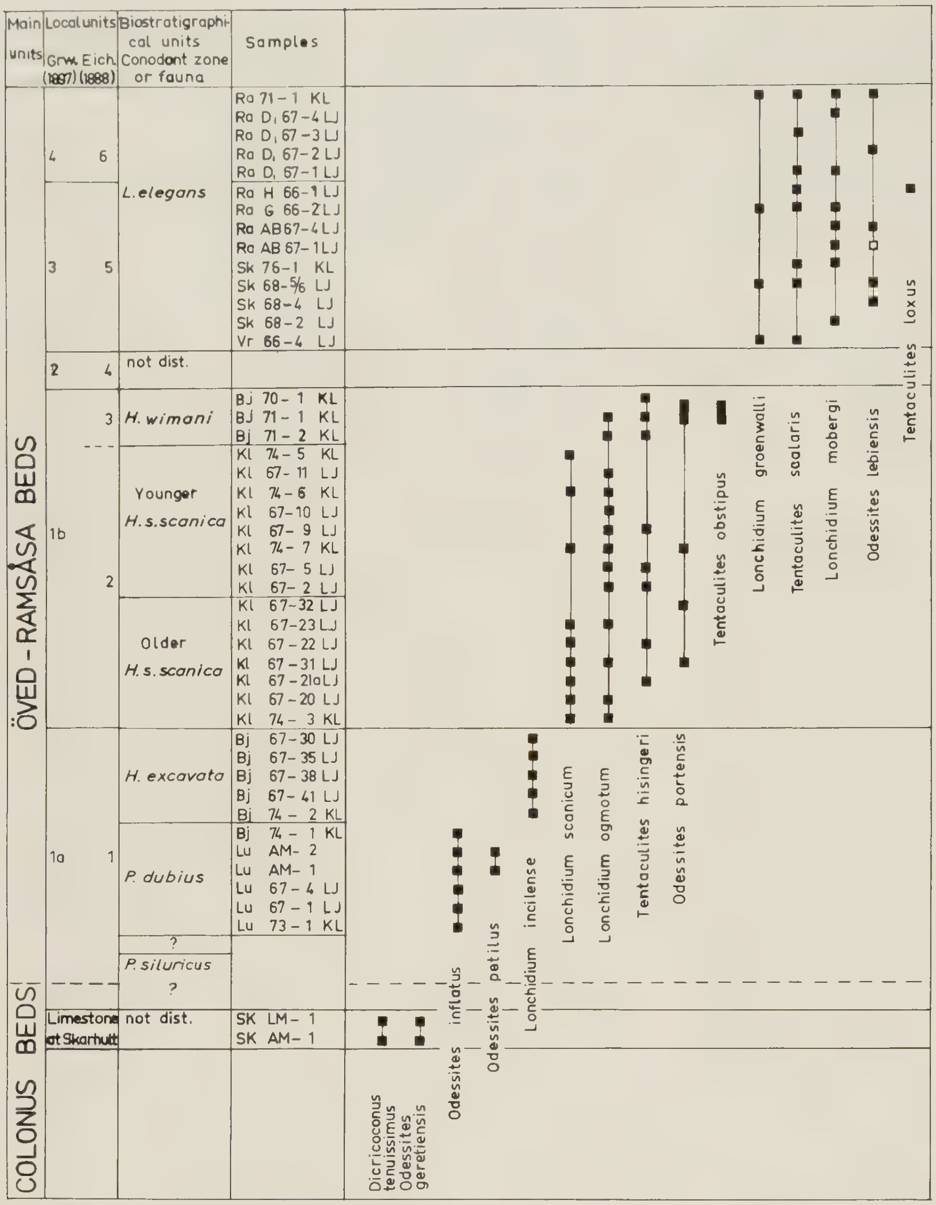


Fig. 69. Distribution of tentaculitid species in the *Colonus* Shale and the Öved-Ramsåsa Beds of Scania. Filled squares represent typical populations, open squares represent less confidently assigned specimens. The samples are arranged stratigraphically. Note that samples from Ramsåsa 4 (Ra D_1) derive from approximately the same stratigraphical horizon.

samples of the section at Bjärsjölagård 1, in which *Lonchidium incilense* is found exclusively in beds with the *Hindeodella excavata* fauna *sensu* Jeppsson (1974), cf. Fig. 69. This difference in distribution probably reflects the failure to obtain any tentaculitid material from samples with the *Pelekysgnathus dubius* fauna at Bjärsjölagård 1 and at Klinta. More systematic sampling for tentaculitids might diminish the difference.

Two of the species just discussed, *Odessites petilus* and *Lonchidium incilense,* are unknown from Gotland.

The next tentaculitid assemblage in Scania is easily distinguished from the preceding fauna, which is well demonstrated in Bjärsjölagårdborrningen 1 (Fig. 70), at Bjärsjölagård 1 and at Klinta. The assemblage comprises four species, *Lonchidium ogmotum, L. scanicum, Tentaculites hisingeri* and *Odessites portensis,* which appear almost simultaneously. Their distribution is particularly well seen at Klinta. *Lonchidium scanicum, Tentaculites hisingeri* and *Odessites portensis* occur up to the top of unit *1b* (*sensu* Grönwall 1897), while *Lonchidium ogmotum* has not been found in beds above the Bjärsjölagård Limestone at Bjärsjölagård 2, i.e. in beds with the *Hindeodella wimani* fauna of Jeppsson (1974). The distribution of these tentaculitids in the borehole Bjärsjölagårdborrningen 1 is incompletely known because no tentaculitids have been found in the biostromal Bjärsjölagård Limestone. Besides, the samples available from the upper part of the core are rather few. Neither has material been available from the corresponding level in the borehole Bjärsjölagårdborrningen 2. The latter core, together with that from Klintaborrningen 1, will doubtless bridge this gap in our knowledge of the stratigraphical distribution of tentaculitids below the yellow sandstone, unit *2* of Grönwall (1897).

At Klinta, a specimen definitely of *Tentaculites obstipus* has been found in museum material labelled "Zone 1

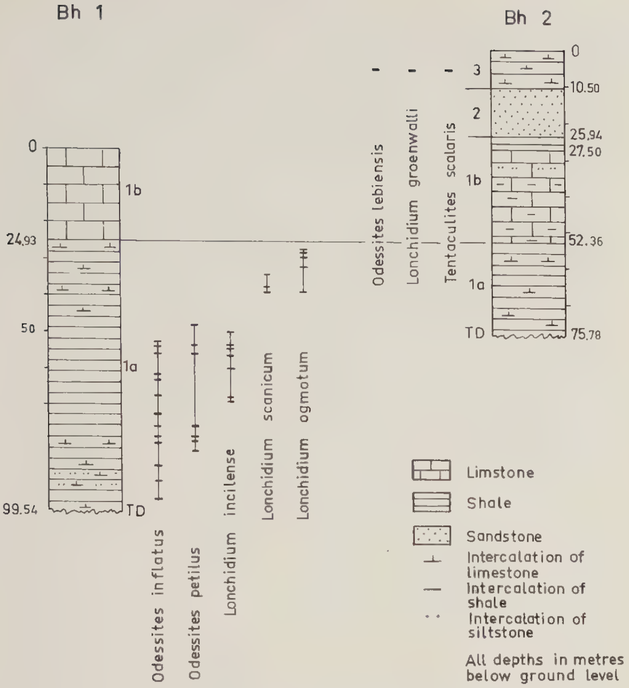


Fig. 70. Distribution of tentaculitid species in the boreholes Bjärsjölagårdborrningen 1 (Bh 1) and Bjärsjölagårdborrningen 2 (Bh 2), Scania. The units 1a, 1b, 2, and 3 are those of Grönwall (1897) for subdivision of the Öved-Ramsåsa Beds in Scania. For a description of the boreholes, see Appendix.

Grönwall/ Zone 3 Eichstädt". The high level within unit *1* (*sensu* Grönwall 1897) is confirmed by one fragmentary specimen from Bjärsjölagård 2 from a lithology corresponding well to that of the calcareous, micaceous *Pteronitella retroflexa*-rich shales which form the top beds in the quarry at Bjärsjölagård 2.

The tentaculitids in the lower Öved-Ramsåsa Beds, unit *1* of Grönwall (1897), seem to confirm his sub-division (Grönwall 1897: 207–208) into two units, *1a* and *1b,* based on the sequence at Bjärsjölagård. Unit *1a* was regarded as equivalent to unit *1* of Eichstädt (1888) at Klinta, and unit *1b* with Eichstädt's units *2* and *3*. Jeppsson (1974, Fig. 6) referred Grönwall's unit *1a* to Eichstädt's unit *2,* but this must be considered incorrect if Grönwall's (1897: 208) original definition is followed. The distribution of tentaculitids in this interval is known rather well both at Klinta and Bjärsjölagård, so there is an interesting control on the correlation of Grönwall's and Eichstädt's units. In the core of Bjärsjölagårdborrningen 1, the beds defined as unit *1a,* i.e. the sequence below 25 m in the borehole, contains two faunas. The lower fauna comprises *Odessites inflatus, O. petilus,* and *Lonchidium incilense* and extends up to 49.7 m below ground level, the higher comprises *Lonchidium scanicum* and *L. ogmotum* and reaches at least up to the base of the Bjärsjölagård Limestone. The higher beds containing the lower fauna form the samples low in the section at Bjärsjölagård 1, up to a level exposed 133 m NW of the bridge. Unfortunately, a fault between here and the biostrome corresponding to the Bjärsjölagård Limestone (base of unit *1b*) about 40 m NW of the bridge makes it impossible to find the vertical distance from here to the base of unit *1b.* The lower fauna is not known from the outcrops at Klinta, but there is probably a good chance of finding it in the core of the borehole Klintaborrningen 1.

The upper fauna at Bjärsjölagårdborrningen 1 is well represented up to the very top of the sections at Klinta, which are referred to unit *2* of Eichstädt (1888). As in the shales overlying the Bjärsjölagård Limestone at Bjärsjölagård 2, this fauna, except for *Lonchidium ogmotum,* continues up to a level which corresponds to unit *3* (Eichstädt 1888) or the *Hindeodella wimani* fauna of Jeppsson (1974). The occurrence of *Tentaculites obstipus* at this level both at Bjärsjölagård and Klinta is good evidence for their equivalence. The vertical distribution of *Tentaculites hisingeri* is notable. The species has not been found in the core of Bjärsjölagårdborrningen 1 but occurs above the Bjärsjölagård Linestone in the quarry at Bjärsjölagård 2. At Klinta it appears rather low in unit *2* *sensu* Eichstädt (1888). This seems to indicate that unit *2* of Eichstädt is either equivalent to the Bjärsjölagård Limestone (unit *1b*), as was originally suggested by Grönwall (1897), or at least to part of it. Jeppsson (1974: 11) also indicates this; the correlation seems to match his, because his faunas in the Klinta sections fall between those in uppermost unit *1a* and lowermost unit *1b* at Bjärsjölagård 1.

As was pointed out earlier, it is difficult to correlate, using tentaculitids, uppermost unit *1* (Grönwall 1897) with the highest beds on Gotland. The youngest faunas in Scania in this unit occur in the late Eke-Hamra Beds interval. The distribution of *Tentaculites hisingeri, T. obstipus* and *Lonchidium scanicum* up to the yellow sandstone, unit *2* of Grönwall (1897), gives the impression that levels within the latter unit must correspond to the uppermost levels on Gotland, the Hamra-Sundre Beds. The distributions of palaeocope ostracodes (Martinsson 1967) and conodonts (Jeppsson 1974) make this a reasonable assumption.

Unfortunately, the yellow sandstone forming unit *2* of Grönwall (1897) does not contain any tentaculitids nor any other useful fossils. The next tentaculitid fauna to appear is a completely new association without similarities to preceding faunas. Instead, it correlates well with low levels in the Podlasie Beds of the subsurface sequence of Poland.

The earliest samples with tentaculitids from unit *3* (*sensu* Grönwall 1897) of the Öved-Ramsåsa Beds come from slightly above the yellow sandstone, unit *2*. In the core of the borehole Bjärsjölagårdborrningen 2 this level is ca. 5 metres above the sandstone, at Klinta "slightly above the yellow sandstone" according to the label accompanying a sample in the museum collection of the Palaeontological Department in Lund. There is still a sequence of ca. 5 metres immediately above the yellow sandstone which has not been analysed biostratigraphically, so there remains a theoretical possibility that these beds could be of pre-Downtonian age. However, the uniform lithology of the beds makes it likely that they represent one sedimentological cycle. A detailed study of the palaeocope ostracode fauna of this level in the cores of Bjärsjölagårdborrningen 2 and Klintaborrningen 1 will probably clarify their age.

The museum sample from Klinta mentioned earlier has good specimens of the ostracode *Frostiella groenvalliana,* thus this sample can be given a definitive age. This ostracode has also been found in several samples from the Skartofta area, in material collected from outcrop and analysed for conodonts by Jeppsson (1974: 50). These Skartofta localities and Vrangelsborg 1 near Klinta probably exhibit the lowest levels available now within unit *3*. All are characterized by *Frostiella groenvalliana.* The tentaculitid fauna is prolific and contains *Lonchidium groenwalli, L. mobergi, Tentaculites scalaris,* and *Odessites lebiensis.* These species continue up into the red beds which form the top of unit *3* and the whole of unit *4*. In the top of unit *3*, a fifth species, *Tentaculites loxus,* occurs sparsely. This species is obviously rather restricted vertically and has only been found at two localities, Ramsåsa 3 and 10, probably in beds close in age. *Odessites lebiensis* is the most common species, followed by *Lonchidium groenwalli.*

The occurrence of *Odessites lebiensis* in the upper two units of the Öved-Ramsåsa Beds provides a good correlation of these beds with horizons in the Podlasian sequence of northern Poland. There, *O. lebiensis* is restricted to a level in the basal division of the Podlasie Beds as defined on ostracode and trilobite evidence (Zagora 1972), i.e. the zone of *Neobeyrichia incerta* and *Acastella prima* (Tomczykowa & Witwicka 1974). *Lonchidium mobergi* may occur in this zone (described as *Tentaculites schlotheimi* by Hajłasz 1974: 470–471, Pl. 6: 3) and would corroborate the correlation. Better evidence for this correlation, using palaeocope ostracodes, was given by Martinsson (1964, 1967).

From various levels in the four zones above the basal zone in Poland (Tomczykowa & Witwicka 1974), six tentaculitid species have been reported (Hajłasz 1974). However, the identification of at least two, "*Tentaculites schlotheimi* Koken" and "*Tentaculites tenuis* Sowerby", must be seriously questioned. The former name was assigned to a Devonian species, but inadequately described, by Koken (1889), the latter species was described from a level low in the Ludlovian of Great Britain, again incompletely and on poorly preserved material (Sowerby 1839). The association of *Tentaculites scalaris* von Schlotheim and *Lonchidium inaequale* d'Eichwald in the upper Podlasian fits with their occurrence in the Ohesaare Beds in Estonia, especially as there they are commonly associated with *Nodibeyrichia tuberculata.* As was mentioned previously, the *N. tuberculata* – *Tentaculites scalaris* association can be proved from the Swedish part of the Baltic Sea too, i.e. at Hoburgs Bank.

It is evident that further examination of the tentaculitid faunas from the post-Ludlovian of the Baltic area may enable use of these fossils for stratigraphy. That tentaculitids may be useful to define the Silurian-Devonian boundary is indicated by the occurrence in Poland (Hajłasz 1974) of different species around this interval. However, thorough revision of the younger faunas described previously (d'Eichwald 1860, Ljashenko 1958 and Hajłasz 1968, 1974) is necessary to satisfy modern demands on descriptions and illustrations.

Summary

The morphology, taxonomy, ecology and stratigraphical value of the Silurian tentaculitid faunas of Gotland and Scania have been examined. On Gotland, material comes from 395 localities, in Scania, from 32 localities. It derives from different lithologies representing various sedimentary environments. Several tens of thousands of tentaculitid specimens have been examined. Most of them exhibit excellently preserved morphological characters which have been revealed by extensive use of scanning electron microscopy (SEM).

In order to describe the morphology of the tentaculitids, special terms have been introduced, most of which are new to work on tentaculitids.

Based on a detailed study of the external and internal morphology of the tentaculitids, a number of new taxa have been established. One new family is introduced, Gotlandellitidae, represented by a new genus, *Gotlandellites. G. areolatus* n. sp. and *G. visbyensis* n. sp. are the only species, the latter bering the type species. The rest of the fauna is represented by four families, three of which are considered in this paper, i.e. Tentaculitidae Walcott, Volynitidae Ljashenko, and Rossiitidae Ljashenko. The fourth family, Uniconidae Ljashenko, cannot be elaborated at present because of unfavourable preservation of the material available.

The family Tentaculitidae is represented by four genera, one of which is new, and thirteen species, twelve of which are new. These include:
Tentaculites gothemensis n. sp., *T. hisingeri* n. sp., *T. limatulus* n. sp., *T. liquis* n. sp., *T. loxus* n. sp., *T. obstipus* n. sp., *T. scalaris* von Schlotheim; *Seretites? cataractae* n. sp., *S.? exilis* n. sp., *S.? versabilis* n. sp.; *Turmalites follingboensis* n. sp., *T. slitiensis* n. sp.; *Tractabilopsis serratus* gen. et sp. nov. Volynitidae is represented by *Lonchidium extensum* n. sp., *L. groenwalli* n. sp., *L. groetlingboense* n. sp., *L. incilense* n. sp., *L. mobergi* n. sp., *L. ogmotum* n. sp., *L. scanicum, L. umidestre* n. sp.; *Odessites geretiensis* n. sp., *O. inflatus* n. sp., *O. lauensis* n. sp., *O. lebiensis* (Zagora), *O. majstriensis* n. sp., *O. petilus* n. sp., *O. portensis* n. sp., *O. prolatus* n. sp.; *Podolites hedei* n. sp., *P. paeninsulicola* n. sp., *P. ternatus* n. sp.; *Volynites muldiensis* n. sp., *V. scalpratus* n. sp. Rossiitidae is represented by *Dicricoconus acutalis* n. sp., *D. aemulus* n. sp., *D. clintianus* n. sp., *D. cracens* n. sp., *D. gutnicus* n. sp., *D. svarvariensis* n. sp., *D. tenuissimus* (Hede), *D. valliensis* n. sp.

The tentaculitids examined occur in lithologies laid down in various environments, but with a preference for muddy soft bottoms with low to moderate wave and current action. Reef environments and substrates of coarse detrital material were less favourable to tentaculitid populations. The bathymetry of the seas in which tentaculitids lived was of major importance to their distribution. Thus, maximum abundance is in upper shelf environments, indicated by the nature of the associated fauna and sedimentological features. Environments in which graptolitic shales formed were avoided by the tentaculitids.

Blind's (1969, 1970) theory that tentaculitids were benthic during their adult growth stage and lived inserted partly into the substrate in a vertical, apex-down position finds support from detailed examination of the conch morphology, ultrastructure, and the mode of occurrence of epizoans. This examination also indicates that tentaculitids were suspension feeders. Some conclusions drawn could be used to discuss zoological affinity. However, no attempt is made to launch a new proposal in this matter; much remains to be done before their position within the animal kingdom can be clarified. It may be concluded, though, that they did not belong to the molluscs, which has been one major hypothesis for more than a century. Morphological characters and ecological features of the tentaculitids suggest an affinity to lophophorates, i.e. bryozoans, brachiopods and phoronids. Yet there are important morphological differences from these phyla.

One purpose of this study has been to establish the stratigraphical value of thick-walled tentaculitoids and this has been achieved. The Silurian tentaculitids of Gotland and Scania described here have vertical distributions in which the various species have short ranges. Thus, their stratigraphical properties may be compared with e.g. palaeocope ostracodes, chitinozoans and conodonts. In addition, the horizontal distribution is good and the tentaculitids occur in different facies realms. This enables correlation of contemporaneous strata of different lithologies. A good correlation may be made between the tentaculitid faunas of Gotland and Scania. It is possible to support the correlations produced from studies of palaeocope ostracodes and conodonts. Few comparisons have been made with faunas from other areas, but those faunas examined and available in literature indicate that tentaculitids are useful for intrabasinal correlation. Their small size and often high abundance make them valuable for biostratigraphical analyses of core material.

No formal tentaculitid zonation is given here because, first, faunas from other areas than Sweden must be checked and the Llandoverian tentaculitids must be studied. However, it is clear that such a zonation within the Balto-Scandian area can be established.

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Appendix: Locality list

[With regard to the use of miniprint in *Fossils and Strata,* see the inside of the back cover.]

GOTLAND

AJMUNDE 1, *Klinteberg Beds*, Klinteberg Marl, top. Light grey, calcareous mudstone. MS 864. Tentaculitids: *Dicricoconus aemulus*.

ALBY 1, *Slite Beds*, Slite Marl. Light grey and greenish-grey, fine grained argillaceous limestone and brownish-grey marl. MS 253, 263, 672. G 73-65 KL. Tentaculitids: *Dicricoconus gutnicus, Turmalites follingboensis*.

ALBYBORRNINGEN 1, 641415 168915 (CK 8051 0975), ca. 4500 m SE of Rute church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Temporary excavation ca. 50 m W of the road, ca. 350 m SSW of the southernmost crossroads at Alby. The excavation was made for the drill mud pit required for OPAB borehole Alby 1.

Slite Beds, Slite Marl. Alternating thin beds of soft, light grey marlstone and argillaceous limestone. G 73-35 KL, G 75-2 KL. Tentaculitids: *Dicricoconus gutnicus*.

ALLEKVIA 1, 639042 165679 (CJ 4645 8858), ca. 2200 m W of Endre church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Shallow ditch exposure immediately E of the small road to Allkviänge (marked as a path on the topographical map), ca. 425 m SSW of the crossroad at Allekvia.

Reference point: Yellow painting on a post 1 m W of the exposure.

Slite Beds, Slite Marl. Soft greenish-grey marl and marlstone. G 73-41 KL, Got 74-35 SB. Tentaculitids: *Alternatus*? sp., *Dicricoconus acutalis, D. clintianus, D. gutnicus, Turmalites follingboensis, T. slitiensis*.

ALNÄSAVIK 1, 642832 169956 (CK 9197 2307), ca. 3200 m NE of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Shore exposure in the NE corner of Alnäsavik, ca. 150 m WSW of point 5.20.

Slite Beds, Slite Marl. Dense bluish-grey marlstone. G 73-10 KL. Tentaculitids: *Tractabilopsis serratus*.

AMLINGS 1, *Hemse Beds*, Hemse Marl, northwestern part. Dense, light greenish-grey, argillaceous limestone and soft grey marl. MS 77, 155, 304, G 75-3 KL. Tentaculitids: *Dicricoconus aemulus*?, *D. tenuissimus, Odessites geretiensis*.

ANGMANS 1, 637207 168139 (CJ 6955 6842), ca. 2600 m NW of Östergarn church. Topographical map sheet 6J Roma SO. Geological map sheet Aa 170 Katthammarsvik.

Small ditch section, about 100 m SSE of the intersection of the small road to Storskär and the road to Katthammarsvik.

Hemse Beds, unit *b*. Bluish-grey to grey, argillaceous limestone. Unnumbered SGU sample. Tentaculitids: *Podolites paeninsulicola*.

References: Hede 1921, p. 61 the bottom 24 lines (contains list of fossils).

ANNELUND 1, *Högklint Beds*, upper part. Intercalations of thin, brownish-grey marl in coarse grained limestone rich in stromatoporoids. MS 50, 148, 171, 187, 194, 195, 199, 308, 405. Tentaculitids: None.

ANSARVE 1, *Högklint Beds*, southwestern facies, upper part. Brownish-grey argillaceous limestone. Unnumbered SMNH sample. Tentaculitids: *Turmalites follingboensis*.

ANSARVE 2, *Högklint Beds*, southwestern facies, upper part. Greenish- and brownish-grey marl. MS 631, 644, 688, 440, 719, 720. Tentaculitids: None.

ANSARVE 3, *Högklint Beds*, southwestern facies, upper part. Soft, bluish-grey and yellowish-grey marlstone and marl. G 73-57 KL, G 74-36 KL. Tentaculitids: *Turmalites follingboensis*.

AR 1, 642524 168643 (CK 7865 2100), ca. 6500 m NE of Fleringe church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Quarry, partly filled with water, just north of Sandvik, Bästeträsk and ca. 550 m S of the pier at Ar.

Högklint Beds, upper part. Intercalations of brownish-grey marl in dense limestone. MS 763, Got 75-41 SB. Tentaculitids: *Tentaculites liquis*.

References: Hede 1933, p. 26 bottom nine lines and p. 27, lines 1-4 (contains list of fossils).

ASE 1, 635575 165678 (CJ 4379 5402), ca. 1925 m SE of Lojsta church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.

Excavation for water hole immediately NW of the road, ca. 450 m NE of point 44.4.

Hemse Beds. Bluish-grey marl and argillaceous lime-stone. MS 727. Tentaculitids: None.

References: Hede 1927b, p. 31, line 3 (reference to the area in general).

ASUNDEN 1, *Slite Beds*, unit *g*. Intercalations of light brownish-grey marl in grey limestone. MS 837, 838, 839. Tentaculitids: None

AURGRUNN 1, 642650 16957 (CK 8385 2187), ca. 5650 m WNW of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Shore exposure on the northwestern shore of Aurgrunn, ca. 125 m SSW of the lighthouse.

Högklint Beds Grey artillaceous limestone. Unnumbered SMNH sample. Tentaculitids: *Tentaculites liquis, Turmalites follingboensis*.

References: Hede 1936, p. 12, line 18, p. 14, line 22.

BANKVÄT 1, *Hamra Beds*, unit *b*. Light grey to brownish-grey marl with thin beds of brownish-grey, fine grained, argillaceous limestone. MS 876, 877, G 72-64, -65, -66, -67, -68, -69, -70, all KL. Tentaculitids: *Lonchidium extensum, L groetlingboense, L. umidestre, Tentaculites hisingeri*.

BARA 1, *Halla Beds*, Bara Oolite. Whitish-grey, oolitic limestone. G 72-17 KL, G 74-10 KL. Tentaculitids: None

BARKARVEÅRD 1, *Hamra Beds*, unit *c*. Brownish-grey, silty marl and fine grained, argillaceous limestone. Got 75-1 SB. Tentaculitids: *Lonchidium groetlingboense, Lonchidium umidestre, Tentaculites hisingeri*.

BÅTA 1, *Slite Beds, Conchidium tenuistriatum* Beds, lower part. Intercalations of light grey marl in medium grained limestone. MS 89, 404, 789. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*?, *Turmalites follingboensis*.

BINGERSKVARN 1, *Tofta Beds*. Intercalations of brownish-grey marl in fine grained, argillaceous algal limestone. MS 454, 491, 565, 605, G 76-1 KL. Tentaculitids: None.

BJARGES 1, *Mulde Beds*, upper part. Brownish-grey marl and fine grained, argillaceous limestone. MS 773, 868, G 73-74 KL. Tentaculitids: *Alternatus*? sp.

BLÅHÄLL 1, *Mulde Beds*, lower part. Brownish- and bluish-grey marl and dense, argillaceous limestone. MS 463, 795, G 72-30 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus cracens*.

BODARNA 1, *Halla Beds*. Intercalations of light greenish- and brownish-grey marl in dense, argillaceous limestone rich in crinoids and stromatoporoids. MS 827, 849. Tentaculitids: None

BODUDD 1, *Hemse Beds*, Hemse Marl, uppermost part. Dense, bluish-grey, calcareous and argillaceous silt-stone, and fine grained silty limestone. G 72-92, -93, -94, -95, all KL. Tentaculitids: None.

BODUDD 2, *Eke Beds*, lowermost part. Greenish-grey, silty marl and silty algal limestone. G 72-96 KL. Tentaculitids: None.

BOFRIDE 1, *Klinteberg Beds*, upper part. Intercalations of yellowish-brown marl in fine grained limestone. MS 634, 635, G 72-24 KL. Tentaculitids: None.

BOGEKLINT 2, *Slite Beds*, outlier of unit *g*. Intercalations of yellowish-grey marl in coarse grained limestone rich in crinoids. MS 443. Tentaculitids: None.

BOLARVE 1, 639137 165715 (CJ 4688 8950), ca. 1250 m SSW of Hejdeby church. Topographical map sheet 6J Roma V & SO. Geological map sheet Aa 189 Virby & Lummelunda.

Shallow ditch section immediately east of the road between Hejdeby and Allekvia, ca. 575 m NNE of the cross-roads at Allekvia. The section is now poorly exposed.

Slite Beds, Conchidium tenuistriatum Beds or slightly older. Brownish-grey marlstone. Unnumbered, SGU collection. Tentaculitids: *Dicricoconus gutnicus, D. acutalis, Turmalites follingboensis, T. slitiensis*.

References: Hede 1921, p. 41, lines 9-39 (contains list of fossils).

BOTES 1, 635529 165160 (CJ 3860 5396), ca. 675 m NW of Gerum church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.

Ditch exposure immediately NW of the ditch and road intersection, ca. 150 m E of the easternmost house at Botes.

Klinteberg Beds, Klinteberg Marl. Yellowish-grey to grey, marl and marlstone with thin beds of fine grained limestone. G 74-32 KL, G 75-4 KL. Tentaculitids: *Dicricoconus aemulus*

BOTES 2, 635530 165180 (CJ 3880 5395), ca. 550 m NW of Gerum church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.

Ditch exposure immediately N of the road, ca. 350 m E of the easternmost house at Botes. The locality is immediately W of a small field road from the main road to the meadow.

Klinteberg Beds, Klinteberg Marl. Yellowish-grey to grey, marl and marlstone with thin beds of fine grained limestone. MS 899, G 75-5 KL. Tentaculitids: *Dicricoconus aemulus*.

BOTVALDVIK 1, 638848 167920 (CJ 6863 8493), ca. 4175 m ENE of Gothem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Shore exposure at the northern pier of the harbour of Botvaldvik.

Reference point: The westernmost end of the northern pier.

Klinteberg Beds, unit *b*. Intercalations of brownish-grey marl in yellowish-grey, slightly oolitic limestone. MS 896, G 72-102 KL. Tentaculitids: *Podolites ternatus*?, Gen. et sp. indet.

References: Hede 1928, p. 58, lines 7-15 (contains list of fossils).

BOTVIDE 1, *Hemse Beds*, Hemse Marl, uppermost part. Light brownish-grey marl and thinly laminated, slightly silty, calcareous mudstone. MS 87, 96, 108, 218, 219, 286, G 72-51 KL, Got 76-19 SB. Tentaculitids: *Odessites inflatus*.

Eke Beds, lowermost part. Intercalations of light brownish-grey marl in fine grained limestone rich in crinoids and stromatoporoids. MS 663. Tentaculitids: None.

BRAJDAURSVIK 1, 642245 169883 (CK 9112 1737), ca. 4000 m SSE of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Shore section on the northern shore of Brajdaursvik, ca. 1525 m E of the triangulation point 17.9 at Damba.

Slite Beds, Slite Marl. Brownish- and bluish-grey marlstone. Unnumbered SGU sample. Tentaculitids: *Dicricoconus acutalis*.

References: Hede 1936, p. 29, lines 8-9 from the bottom.

BRINGES 2, 632251 165596 (CJ 4045 2095), ca. 4625 m NE of Hamra church. Topographical map sheet 5I Hoburgen SO & 5J Hemse SV. Geological map sheet Aa 152 Burgsvik.

Well, 40 m ENE of the sharp bend in the road, 500 m ENE of the house at Bringes.

Hamra Beds. Brownish-grey marl and argillaceous limestone. MS 601. Tentaculitids. None

BROA 1, *Slite Beds*, Ryssnäs Limestone. Intercalations of brownish-grey marl in coarse grained limestone rich in crinoids and stromatoporoids. MS 447. Tentaculitids: None.

BROTRASKKRÖKEN 1, *Hemse Beds*, middle-upper part. Intercalations of brownish-grey marl in medium grained limestone rich in stromatoporoids. MS 859. Tentaculitids: None.

BURGATAN 1, 634926 165532 (CJ 4184 4766), ca. 1150 m NNE of Hemse church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.

Ditch section along field road, starting at the NW end of Burgatan, Hemse, ca. 260 m NW of the water tower, and continuing ca. 270 m towards the NW along the SW edge of the wood.

Reference point: SE end of ditch.

Hemse Beds, Hemse Marl. Light bluish-grey marl and argillaceous limestone. Got 74-42 SB. Tentaculitids: *Dicricoconus aemulus, D. tenuissimus*.

BURGEN 1, *Burgsvik Beds*, upper part. Intercalations of yellowish-grey marl between crinoidal imestone and fine grained, oolitic limestone. MS 681 Tentaculitids: *Tentaculites obstipus*.

BURGEN 4, *Hemse Beds*, Hemse Marl, southeastern part. Light greenish-grey marl and calcareous, silty mudstone. G 74-24 KL, -25 KL. Tentaculitids: *Odessites inflatus, Tentaculites*? sp.

Eke Beds, lowermost part. Brown, fine grained argillaceous, slightly silty limestone Got 74-21, -22, [illegible] -30, all SB. Tentaculitids: *Alternatus*? sp., *Odessites prolatus*, Gen. et sp. indet.

BURGEN 5, *Eke Beds*, lower part. Brownish-grey, argillaceous limestone. Got 74-31 SB. Tentaculitids: *Odessites prolatus*.

BURGEN 7, *Burgsvik Beds*, uppermost part. Brownish-grey marl, 1.5 m below the Burgsvik-Hamra boundary. G 74-66 KL. Tentaculitids: *Alternatus*? sp., *Odessites portensis, Tentaculites obstipus*.

BURGEN 8, 634840 166857 (CJ 5498 4580), ca. 5525 m ESE of Burs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.

Abandoned quarry immediately N of the road, ca. 225 m NE of the northernmost house at Hemmor and ca. 180 m NE of the first cross roads north of Hemmor.

Burgsvik Beds. Yellowish-grey oolitic limestone. G 72-79 KL. Tentaculitids: Gen. et sp. indet.

BURGEN 9, 634831 166737 (CJ 5378 4580), ca. 4500 m ESE of Burs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.

Abandoned quarry immediately S of the road, ca. 110 m E of the triangulation point at Burgen.

Burgsvik Beds. Intercalations of yellowish-grey marl in yellowish-grey oolitic limestone. G 72-80 KL, -81 KL, G 73-53 KL. Tentaculitids: *Alternatus*? sp., *Tentaculites obstipus*.

References: Hede 1925b, p. 32, lines 11-12, bottom five lines, p. 33, lines 1-18 (contains list of fossils); Manten 1971, p. 406, Fig. 210.

BURGSVIKBORRNINGEN 1, 632524 164986 (CJ 3458 2412), ca. 1725 m WSW of Öja church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik

Borehole situated 50 m NW of the road and 125 m ENE of the windmill SW of Burgsvik. The borehole was drilled in 1915 to a total depth of 128.68 m. The elevation of the well head was 8.25 m above sea level.

Hemse Beds, Hemse Marl. Light grey, slightly micaceous, silty and calcareous shale with thin beds of dense, fine grained limestone. 63.50-128.63. Tentaculitids: *Dicricoconus tenuissimus*.

Eke Beds. Bluish-grey, slightly silty and micaceous marl and argillaceous limestone with algae. 49.60-63.50 m. Tentaculitids: None.

Burgsvik Beds. Dense, grey, slightly calcareous, micaceous mudstone; grey, micaceous, marly sandstone; whitish-grey, calcareous sandstone; light grey oolite and oolitic limestone. 2.38-49.60 m. Tentaculitids: *Odessites portensis, Tentaculites hisingeri, T.* sp. indet.

Hamra Beds. Dense, bluish-grey, fine grained limestone and argillaceous limestone rich in algae. 1.0-2.38 m. Tentaculitids: *Tentaculites hisingeri*.

References: Munthe 1915, p. 346; Hede 1919c, pp. 5-59 (gives full lithological and faunal logs); Hede 1921, p. 62, lines 16-25, Fig. 10 (profile); Munthe 1921b, p. 20, bottom ten lines, p. 21, lines 1-3, Fig. 15, Fig. 16 (profile of the borehole), p. 33, lines 7-15; Hadding 1929, p. 189; Hede 1942, pp. 21-22; Manten 1971, p. 392, p. 393 (Table XX); Laufeld 1974a, p. 161; Larsson 1975, p. 133.

BUSKE 1, *Lower Visby Beds*, top. Light greenish-grey marl and argillaceous limestone. MS 192, 343, G 74-54 KL. Tentaculitids: *Seretites*? *exilis*.

DÄPPS 1, *Mulde Beds*, upper part. Brownish- and greenish-grey marl and dense, argillaceous limestone. MS 267, 273, 298, 301, 310, 399, 400, 401. Tentaculitids: *Alternatus*? sp., *Volynites muldiensis*.

DÄPPS 2, *Mulde Beds*, upper part. Brownish-grey marl and argillaceous limestone. G 74-71 KL. Tentaculitids: *Alternatus*? sp., *Volynites muldiensis*

DAVIDE 1, 634643 165772 (CJ 4402 4466), ca. 1750 m NW of Rone church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.

Ditch exposure immediately NE of the road, ca. 50 m NE of the house. Dump from drainage ditch excavations extends SW-NE for 200 m.

Hemse Beds, Hemse Marl, southeastern part. Light bluish-grey marl and marlstone. Tentaculitids: *Dicricoconus tenuissimus, Odessites inflatus*

DIBJÄRS 1, 638443 166732 (CJ 5650 8178), ca. 525 m SSE of Hörsne church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Shallow section in the lower part of the slope, 125 m NNW of the 3-way junction at Dibjärs, ca. 60 m NE of the road to Horsne.

Klinteberg Beds, unit *a*. Bluish-grey marlstone and argillaceous, occasionally arenaceous limestone. Unnumbered SGU samples. Tentaculitids: *Podolites hedei, Tentaculites gothemensis*.

DJAUPVIKSUDDEN 1, *Hemse Beds*, unit *b* Brownish-grey marl and light greenish- and brownish-grey, fine grained limestone MS 91, 174, 180, 202, 203, 205, 852. Tentaculitids: *Podolites paeninsulicola*.

Hemse Beds, unit *c* Grey, dense, argillaceous limestone. SB (unnumbered samples). Tentaculitids: *Podolites hedei, P. paeninsulicola*.

DJUPVIK 1, *Mulde Beds*, lower part. Bluish-grey marl and dense, argillaceous limestone. Tentaculitids: *Alternatus* ? sp., *Dicricoconus cracens, Volynites muldiensis* ?.

DRAKARVE 1, *Hemse Beds*, Hemse Marl, uppermost part. Greenish-grey, calcareous, slightly silty mudstone. G 75-24 KL. Tentaculitids: *Dicricoconus tenuissimus*.

EJVIDE 1, 635340 163849 (CJ 2538 5307), ca. 4300 m W of Eksta church. Topographical map sheet 6 I Visby SO. Geological map sheet Aa 164 Hemse.

Ditch excavation immediately SW of the road, ca. 150 m NW of the cross roads NW of Ajvide

Mulde Beds. Greenish-grey marl and argillaceous limestone. MS 776, 890, G 73-75 KL. Tentaculitids: *Alternatus* ? sp.

EKE 1, *Eke Beds*, middle part. Intercalations of brownish-grey marl in slightly silty and argillaceous limestone. MS 135. Tentaculitids: None.

ENHOLMEN 1, *Slite Beds*, unit *g*. Intercalations of light greenish-grey marl in dense limestone very rich in stromatoporoids. MS 841. Tentaculitids: None.

ESKE 1, *Hemse Beds*, Hemse Marl, northwestern part. Light bluish-grey marl and marlstone. MS 161, 242. Tentaculitids: *Dicricoconus aemulus*

FÅGELHAMMAR 1, *Hemse Beds*, upper part. Pockets of greenish-grey marl in dense limestone rich in stromatoporoids. MS 853. Tentaculitids: None.

FAKLE 1, *Hemse Beds*, unit *c*. Intercalations of light brownish-grey marl in fine grained limestone rich in stromatoporoids. MS 139, 149, 297, G 74-29 KL. Tentaculitids: *Alternatus*? sp.

FALUDDEN 1, *Sundre Beds*, lower part. Intercalations of brownish-grey marl in fine grained limestone rich in stromatoporoids. G 73-25 KL. Tentaculitids: Gen. et sp. indet.

FÅRÖ KYRKA 2, 642583 169744 (CK 8967 2075), ca. 375 m SE of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Shore exposure 75 m E of the small road to Verkegards, 350 m SSW of the northernmost cross-roads at Fårö church.

Slite Beds, Slite Marl. Brownish-grey marl and argillaceous limestone. G 73-12 KL, G 75-13 KL. Tentaculitids: *Turmalites follingboens*

References: Hede 1936, p. 30, bottom fourteen lines, p. 31, lines 1-6 (contains list of fossils).

FÅRÖ SKOLA 1, *Slite Beds*, Slite Marl. Greenish-grey marl and argillaceous limestone. MS 72, 114, 147, 185, 262, G 73-94 KL. Tentaculitids: *Alternatus* ? sp., *Turmalites follingboensis, T. slitiensis*.

FIE 1, *Hemse Beds*, Hemse Marl, southeastern part. Intercalations of greenish-grey marl in dense, argillaceous limestone MS 76, 236. Tentaculitids: *Odessites inflatus*.

FJARDINGE 1, *Klinteberg Beds*, unit *b* Light greyish-brown marl and argillaceous, slightly silty limestone. MS 777, 878, G 73-62 KL, G 74-60 KL Tentaculitids: *Alternatus* ? sp., *Tentaculites gothemensis* ?.

FOLLINGBO 1, *Slite Beds*, Slite Marl, northwesternmost part. Brownish-grey marl and argillaceous limestone. MS 18, 20, 47, 98, 244, 260, 268, 319, 321, 416, 419, 435. Tentaculitids: *Dicricoconus clintianus, D. gutnicus, Seretites ? versabilis, Turmalites follingboensis, T. slitiensis*.

FOLLINGBO 2, *Slite Beds*, Slite Marl, northwesternmost part. Brownish-grey marl and argillaceous limestone. MS 75, 306, 420. Tentaculitids: *Dicricoconus clintianus, D. gutnicus, Seretites ? versabilis, Turmalites follingboensis*.

FOLLINGBO 3, *Slite Beds*, Slite Marl, northwesternmost part. Brownish-grey marl and fine grained, argillaceous limestone. MS 417, 485, 562. Tentaculitids: *Alternatus* ? spp., *Dicricoconus acutalis, D. clintianus, D. gutnicus, Turmalites follingboensis, T. slitiensis*.

FOLLINGBO 4, *Slite Beds*, unit *g*. Light grey, dense limestone. G 72-16 KL. Tentaculitids: None.

FOLLINGBO 5, *Slite Beds*, Slite Marl, northwesternmost part. Yellowish- to brownish-grey marl and argillaceous limestone. G 72-39 KL. Tentaculitids: *Dicricoconus gutnicus, Turmalites follingboensis, T. slitiensis*.

FOLLINGBO 6, *Slite Beds*, Slite Marl, northwesternmost part. Yellowish- to brownish-grey marl and argillaceous limestone. G 73-1, -2, -3, all KL. Tentaculitids: None.

FOLLINGBO 7, *Slite Beds*, Slite Marl, northwesternmost part. Brownish- and bluish-grey marl and marlstone alternating with argillaceous limestone. G 74-74 KL, Got 74-28 SB. Tentaculitids: *Alternatus*? sp., *Dicricoconus gutnicus, Seretites*? *versabilis, Turmalites follingboensis*.

FOLLINGBO 8, 638757 165335 (CJ 4281 8600), ca. 1975 m NW of Follingbo church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Road cutting immediately east of the road, ca. 35 m NW of the crossroads.

Slite Beds, Slite Marl, northwesternmost part. Brownish- and bluish-grey marl and dense argillaceous limestone. G 75-31 KL. Tentaculitids: *Dicricoconus gutnicus, Turmalites follingboensis*

FOLLINGBO 9, 638756 165401 (CJ 4345 8594), ca. 550 m NNW of Follingbo church. Topographical map sheet 6J Roma NV & SO. Geological map sheet Aa 183 Visby & Lummelunda.

Ditch section immediately east of the road from Rosendal to Gerete, ca. 250 SSW of Rosendal.

Slite Beds, Slite Marl, northwesternmost part. Brownish-grey marlstone and argillaceous limestone. Unnumbered, SGU collection. Tentaculitids: *Seretites*? *versabilis*.

FOLLINGBO 10, 638709 165363 (CJ 4305 8550), ca. 600 m W of Follingbo church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Temporary excavation for foundations of a house (marked on the topographical map sheet), 125 m N of the crossroads immediately south of the point 48.8.

Slite Beds, Slite Marl, northwesternmost part. Thin beds of brownish-grey marlstone and argillaceous, occasionally arenaceous, limestone. Unnumbered, SGU collection. Tentaculitids: *Seretites*? *versabilis*.

Remarks: Abundant material from the excavation was collected in 1933 by J.E. Hede. This material is now kept at the Geological Survey of Sweden.

References: Hede 1940, p. 60, line 23- p. 61, lines 1-9 (contains list of fossils).

FOLLINGBO 11, 638700 165360 (CJ 4299 8542), ca. 625 m W of Follingbo church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Shallow ditch section immediately W of the old road 143, ca. 60 m WSW of point 48.8.

Slite Beds, Slite Marl, northwesternmost part. Brownish- and yellowish-grey marlstone and argillaceous limestone. Unnumbered, SGU collection. Tentaculitids: *Seretites*? *versabilis*.

FORSE 1, *Klinteberg Beds*, lower part. Intercalations of greenish-grey marl in dense limestone rich in stromatoporoids. MS 766. Tentaculitids: *Tentaculites gothemensis*?.

FRIGGARS 1, 642450 169876 (CK 9088 1932), ca. 2250 m SE of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fåro.

Cliff section ca 230 m ENE of the windmill north of Hammars.

Reference level: The boundary between the Slite Marl and Ryssnäs Limestone.

Slite Beds, Slite Marl, uppermost part Greenish- and brownish-grey marl and argillaceous limestone. G 73-13 KL, -14 KL Tentaculitids: *Alternatus*? sp., *Dicricoconus gutnicus, Turmalites follingboensis, T. slitiensis*?.

Slite Beds, Ryssnäs Limestone. Dense, grey to greenish-grey limestone with thin intercalations of marl. G 73-15 KL. Tentaculitids: None.

References: Hede 1936, p. 31, lines 13-27.

FROJEL 4, 635944 164362 (CJ 3096 5870), ca. 280 m N of Fröjel church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Road section immediately E of the new road, ca. 3-0 m N of point 26.73 at Fröjel. The section is ca. 125 m long.

Reference point: The intersection of the power line and road.

Klinteberg Beds, lowermost part. Brownish-grey marl. Got 75-5 SB. Tentaculitids: *Podolites hedei*?, *Podolites* sp.

FURILDEN 1, 641099 169036 (CK 8148 0650), ca. 5560 m E of Hellvi church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shallow ditch exposure 525 m NE of the easternmost point of the causeway to Furilden.

Slite Beds, Slite Marl. Brownish-grey marl and argillaceous limestone. G 74-52 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus acutalis, D. clintianus, D. gutnicus*.

GALGBERGET 1, *Tofta Beds*, lower part. Brownish-grey marl, 0-5 cm above the reference level. MS 449, G 72-46 KL. Pockets of brownish-grey marl 75 cm (G 72-47 KL), and 100 cm (G 72-48 KL) above the reference level. Tentaculitids: None.

GANDARVE 1, *Halla Beds*. Greyish-brown marl and argillaceous, fine grained limestone. MS 131, 144, 153, 163, 169, 172, 604, G 74-18 KL. Tentaculitids: *Alternatus*? sp., *Volynites* cf. *muldiensis*

GANE 1, *Slite Beds*, Slite Marl. Brownish-grey marl and argillaceous limestone. MS 323, 458, G 74-11 KL, -12 KL. Tentaculitids: *Dicricoconus acutalis, D. clintianus, D. gutnicus, Seretites*? *versabilis, Turmalites follingboensis, T. slitiensis*.

GANE 2, 639677 167346 (CJ 6355 9363), ca. 4075 m SW of Boge church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Former railway section and ditch section (ditch not marked on the topographical map), 0-3-0 m SE of the triangular point 22.1 at Graute.

Reference point: Intersection of the former railway embankment and road.

Slite Beds, Slite Marl. Brownish- and yellowish-grey marl and argillaceous limestone. G 74-13, -14, -15, all KL. Tentaculitids: *Dicricoconus acutalis*, *D. gutnicus*, *Seretites? versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

References: Hede 1928, p. 20 bottom six lines, p. 21, lines 1-25 (contains list of fossils).

GANNES 1, *Hemse Beds*, unit *d*, base. Intercalations of greenish- and brownish-grey marl in dense limestone rich in stromatoporoids. MS 197, 255, 461, G 74-35 KL. Tentaculitids: None.

GANNOR 1, *Hemse Beds*, Hemse Marl, uppermost part. Light greenish-grey marl and marlstone. MS 48, 71 G 1 AM, SMNH (unnumbered). Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

GANTHEM 1, *Klinteberg Beds*, unit *c*. Intercalations of greenish-grey marl in dense limestone rich in bryozoans. G 73-39 KL. Tentaculitids: None.

GANDARVE 1, 635221 165149 (CJ 3825 5090), ca. 1675 m NW of Fardhem church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.

Ditch section immediately NE of the road and ditch intersection, ca. 300 m NW of the northwesternmost house at Överbunde.

Hemse Beds, Hemse Marl. Bluish-grey marl and marlstone. MS 620. Tentaculitids: None.

GARDRUNGS 1, *Slite Beds*, *Conchidium tenuistriatum* Beds. Intercalations of brownish-grey marl in coarse grained crinoidal limestone. MS 99, 104. Tentaculitids: None.

GERETE 1, *Hemse Beds*, Hemse Marl, northwestern part. Bluish-grey marl and marlstone, and fine grained, argillaceous limestone. MS 698, 891, 892, G 72-26 KL, G 73-54 KL, Got 74-41 SB. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites geretiensis*.

GISLE 1, *Hamra Beds*, unit *a*. Brownish- and bluish-grey marl and argillaceous limestone rich in algae. G 75-16 KL. Tentaculitids: *Lonchidium scanicum*.

GISSLAUSE 1, *Slite Beds*, unit *g*. Intercalations of greenish-grey marl in coarse grained limestone rich in stromatoporoids. G 73-64 KL. Tentaculitids: *Turmalites slitiensis*.

GLASSKÄR 1, *Burgsvik Beds*, lower part. Grey to brownish-grey marl and argillaceous limestone. MS 888, 889, G 73-51. Tentaculitids: *Alternatus?* spp., *Odessites lauensis*?.

GLÄVES 1, *Hemse Beds*, Hemse Marl, southeastern part. Greenish- and brownish-grey marl and marlstone. MS 229, 295. Tentaculitids: *Odessites inflatus*.

GLÄVES 2, 635016 166478 (CJ 5127 4781), ca. 5570 m WSW of När church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Ditch section N of the road, ca. 310 m W of point 16.23.

Hemse Beds, Hemse Marl, southeastern part. Brownish-grey marl. Got 76-9 SB. Tentaculitids: *Dicricoconus aemulus*, *D. tenuissimus*, *Odessites inflatus*.

GLÄVES 4, 635005 166457 (CJ 5108 4772), ca. 5790 m WSW of När church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Ditch excavation S of the road, ca. 520 m WSW of point 16.23.

Hemse Beds, Hemse Marl, southeastern part. Brownish-grey marl. Got 76-8 SB. Tentaculitids: *Dicricoconus aemulus*, *D. tenuissimus*, *Odessites inflatus*.

GNISVÄRD 1, *Upper Visby Beds*. Grey marl and dense argillaceous limestone. MS 35, 37, 42, 109, 142, 151, 152, 158, 175, 181, 557, 641, G 72-7 KL, G 74-67 KL. Tentaculitids: *Gotlandellites areolatus*, *Seretites? exilis*, *S.? cataractae*.

GODRINGS 2, *Halla Beds*, uppermost part. Greenish-grey marlstone and argillaceous limestone. G 73-38 KL. Tentaculitids: None.

GOGS 1, *Hemse Beds*, Hemse Marl, uppermost part. Brownish-grey marl and fine grained argillaceous limestone. MS 243, 276, 278, G 73-49 KL, G 74-64 KL, 71 G 2 AM. Tentaculitids: *Odessites inflatus*.

GOTHEMSHAMMAR 1, *Halla Beds*, unit *c*, upper part. Brownish-grey marl and fine grained, argillaceous limestone. MS 625, 645, 669, 895, G 72-104 KL, 73 G 1 AM. Tentaculitids: *Podolites hedei*, *P. ternatus*, *Tentaculites gothemensis*.

GOTHEMSHAMMAR 2, *Halla Beds*, unit *c*, upper part. Brownish-grey marl, marlstone and argillaceous limestone. MS 646, G 72-106 KL. Tentaculitids: None.

Klinteberg Beds, unit *a*, lower part. Brownish- and greenish-grey marl and argillaceous limestone. MS 647, G 72-105 KL. Tentaculitids: *Alternatus?* sp., *Podolites hedei*, *P. ternatus*, *Tentaculites gothemensis*.

GOTHEMSHAMMAR 3, *Klinteberg Beds*, unit *a*, lowermost part. Brownish- and greenish-grey marl and argillaceous limestone. G 72-103 KL. Tentaculitids: None.

GRAUTE 1, 639736 166942 (CJ 5957 9452), ca. 1425 m SSE of Hejnum church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Temporary excavation for water hole E of the road, ca. 350 m NNW of point 53.2 S of Graute.

Slite Beds. Intercalations of brownish-grey marl in dense limestone. MS 700. Tentaculitids: None.

References: Hede 1928, p. 19, lines 24-25 (reference to the area in general).

GROGARNS 1, *Hemse Beds*, unit *c*. Brownish-grey marl and argillaceous limestone. MS 769, 71 G 3 AM. Tentaculitids: *Podolites paeninsulicola*.

GROGARNSHUVUD 1, *Hemse Beds*, unit *c*. Intercalations of brownish-grey marl and fine grained, argillaceous limestone. MS 24, 54, 95, 258, 338, 567, 568, 609, 610, 611, 612, 613, 862, Got 74-18 SB. Tentaculitids: *Alternatus?* spp., *Odessites geretiensis*.

GROGARNSHUVUD 2, *Hemse Beds*, unit *c*. Brownish-grey marl and argillaceous limestone. G 72-71, -72, -73 (all KL). Tentaculitids: None.

GRUNDÅRDEN 1, 633532 164536 (CJ 3086 3453), ca. 3650 m WNW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Dumped rock from the excavation of the small fishing harbour, immediately NW of the small house.

Hemse Beds, Hemse Marl, northwestern part. Light bluish-grey marlstone and calcareous shale. G 72-90 KL. Tentaculitids: *Dicricoconus tenuissimus*.

GRUNNUDDEN 1, 641625 169336 (CK 8487 1152), ca. 3500 m SE of Bunge church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shore exposure ca. 350 m NNW of the southern point of the peninsula.

Slite Beds, Slite Marl. Bluish-grey marl and argillaceous limestone. G 73-33 KL. Tentaculitids: *Alternatus?* sp., *Dicricoconus acutalis*, *D. clintianus*, *D. gutnicus*, *Seretites? versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

References: Manten 1971, p. 316, lines 21-23.

GRUNNUDDEN 2, 641624 169326 (CK 8477 1129), ca. 3650 m SE of Bunge church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shore exposure, ca. 100 m NE of the point of Grunnudden.

Slite Beds, Slite Marl. Light grey to bluish-grey, fine grained, argillaceous limestone, alternating with bluish-grey marlstone. Unnumbered SGU samples. Tentaculitids: *Dicricoconus acutalis*, *D. gutnicus*, *Seretites? versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

References: Hede 1933: 50, line 4-28 (contains list of fossils).

GRUNNUDDEN 3, 641594 169324 (CK 8472 1120), ca. 3675 m SE of Bunge church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shore exposure, ca. 25 m NE of the point of Grunnudden.

Slite Beds, Slite Marl. Light grey to bluish-grey, fine grained, argillaceous limestone alternating with bluish-grey marlstone. Unnumbered SGU samples. Tentaculitids: *Seretites? versabilis*.

GRUNNET 1, 632822 165394 (CJ 3887 2680), ca. 2800 m SE of Fide church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Shore exposure S of the track, ca. 550 m WNW of the southernmost point of the peninsula

Hamra Beds, middle-upper part. Yellowish-brown marl. G 73-80 KL. Tentaculitids: None.

GULLARVE 1, *Slite Beds*, Slite Siltstone, lower part. Intercalations of yellowish-brown marl in calcareous siltstone. MS 678. Tentaculitids: None.

GUSTAVSVIK 1, *Lower Visby Beds*. Grey marlstone and dense argillaceous limestone. MS 25, 26, 53, 67, 94, 100, 129, 133, 138, 214, 252, 487, 606, 642, G 72-1 KL. Tentaculitids: *Alternatus?* sp., *Gotlandellites visbyensis*, *Seretites? exilis*.

GUTENVIKS 1, *Hemse Beds*, unit *c*. Greenish- and bluish-grey marl, marlstone and argillaceous limestone. MS 872, G 72-29 KL, G 73-48 KL, G 74-63 KL, Got 74-29 SB. Tentaculitids: *Alternatus?* spp.

GUTEVÄGEN 1, *Högklint Beds*, unit *a*. Intercalations of light bluish-grey marl in dense, fine grained, argillaceous limestone. MS 3, 46, 64, 70, 97, 248, 265, 277, 289, 451, 651. Tentaculitids: *Alternatus?* sp., *Gotlandellites areolatus*, *Seretites? cataractae*.

GUTEVÄGEN 2, *Högklint Beds*, unit *a*. Intercalations of bluish-grey marl in fine grained, argillaceous limestone. MS 132, 207, 406, G 72-5 KL, -6 KL. Tentaculitids: None.

GYLE 1, *Hemse Beds*, unit *b*. Brownish-grey marl and argillaceous limestone. MS 884, G 73-46 KL. Tentaculitids: *Podolites paeninsulicola*, *P. ternatus*?.

HÄFTINGSKLINT 1, *Upper Visby Beds*, upper part. Greenish-grey marl and argillaceous limestone. MS 710. Tentaculitids: *Gotlandellites areolatus*.

Högklint Beds, unit *a*. Greenish- and brownish-grey marl, marlstone and argillaceous limestone. MS 711, 712, 713, 714, 721, 722, 881, 882, 883, G 73-67 KL, -68 KL. Tentaculitids: *Alternatus?* sp., *Gotlandellites areolatus*, *Seretites? cataractae*.

HAGANÄS 1, *Slite Beds*, Slite Marl, top. Light grey marl and argillaceous limestone. MS 445, 446, 488, 489, 788, G 72-75 KL. Tentaculitids: *Alternatus?* sp., *Dicricoconus acutalis*, *Trastabilopsis serratus*, *Turmalites follingboensis*, *T. slitiensis*.

HÄGELSARVE 1, 638988 166228 (CJ 5188 8762), ca. 1150 m NNE of Ekeby church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Shallow ditch exposure 250 m NE of the crossroads N of Hägelsarve. The locality is in the northernmost part of the timberyard.

Slite Beds, Slite Marl. Brownish-grey marl and argillaceous limestone. G 74-9 KL. Tentaculitids: *Seretites? versabilis*?, *Turmalites follingboensis*?.

HÄGUR 1, 635177 164000 (CJ 2677 5133), ca. 5150 m ENE Eksta church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Drainage ditch section 75 m NW of the road, 550 m SW of the crossroads SW of Hägur. The locality lies ca. 115 m along the field road (not marked on the topographical map) running from a gate 450 m SW of the crossroads mentioned above.

Slite Beds, Slite Marl. Yellowish-grey marl and argillaceous limestone. G 74-69 KL. Tentaculitids: *Dicricoconus clintianus*, *D. gutnicus*, *Seretites? versabilis*?, *Turmalites follingboensis*.

HÄGVIDE 1, *Hemse Beds*, Hemse Marl, southeastern part. Grey marl and dense, argillaceous limestone. MS 5, 82, 230, 235, 284, 291. Tentaculitids: *Odessites inflatus*.

HÄGVIDE 2, 635044 166634 (CJ 5292 4800), ca. 3925 m WSW of Näs church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Large field exposure immediately N of the road, ca 250 m WSW of the southernmost crossroads at Hägvide.

Reference point: The ditch with dumped material at the southwesternmost corner of the fenced field.

Hemse Beds, Hemse Marl, southeastern part. Grey marl and dense, argillaceous limestone. G 74-26 KL. Tentaculitids: *Odessites inflatus*.

References: Munthe *et al.*, 1925, Fig. 7, p. 9, line 4.

HÄGVIDE 3, 635087 166562 (CJ 5223 4848), ca. 4550 m WSW of När church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Ditch exposure W of the field road, ca. 920 m NE of point 16.23. The ditches form a triangle where the eastern point lies immediately W of the road and the opposite N-S side is ca. 200 m from the road.

Reference point: The eastern point of the triangle.

Hemse Beds, Hemse Marl, southeastern part. Grey marl and argillaceous limestone. Got 76-10 SB, -11 SB. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

HAJDUNGS 1, 639203 165774 (CJ 4752 9011), ca. 550 m SSE Hejdeby church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Former ditch section 550-700 m SSE of Hejdeby church.

Slite Beds, Slite Marl. Greenish-grey marl. Tentaculitids: *Alternatus?* sp., *Dicricoconus acutalis*, *D. clintianus*, *D. gutnicus*, *Turmalites follingboensis*, *T. slitiensis*.

References: Hede 1940, p. 61, lines 10-32 (contains list of fossils).

HALLBJÄNS 1, *Hamra Beds*, unit *c*. Intercalations of brownish-grey marl in coarse grained crinoidal limestone. MS 770, 771. Tentaculitids: *Alternatus?* sp., *Odessites majstriensis*, *Tentaculites hisingeri*.

HALLSARVE 1, *Eke Beds*, lower part. Intercalations of light yellowish-brown stone. MS 662. Tentaculitids: Gen. et sp. indet.

HALLSARVE 2, 635410 167052 (CJ 5737 5130), ca. 800 m ESE of Lau church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Ditch section, ca. 200 m NNW of the main crossroads NW of Kauparve, 100 m NE of the main road to Lau.

Hemse Beds, uppermost part. Bluish-grey and brownish-grey marlstone and thin argillaceous, fine grained limestone. Unnumbered SGU samples. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

References: Hede 1921, p. 58 bottom three lines - p. 59 top 15 lines (contains list of fossils); Hede 1925b, p. 24 bottom nine lines - p. 25 top lines (contains list of fossils).

HALOR 1, *Eke Beds*, upper part. Brownish-grey marl and slightly micaceous and silty, argillaceous limestone. MS 313, 327. Tentaculitids: *Dicricoconus* sp., *Odessites portensis*, *O. prolatus*, *Tentaculites obstipus*.

HALOR 2, *Eke Beds*, middle-upper part. Brownish-grey, fine grained, argillaceous limestone rich in algae. G 74-21 KL. Tentaculitids: *Odessites prolatus*.

HALLS HUK 1, *Upper Visby Beds*. Brownish-grey marl and argillaceous limestone. MS 102, 275. Tentaculitids: *Gotlandellites areolatus*.

HAMMAREN 1, 635310 167200 (CJ 5876 5022), ca. 2550 m SE of Lau church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.

Shallow ditch exposure immediately S of the road, ca. 875 m WNW of the roadbridge over Närkån.

Hemse Beds. Brownish- and bluish-grey marl. MS 661. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

HAMMARS 1, *Hemse Beds*, unit *c*. Bluish-grey marl. MS 466, 553, 626. Tentaculitids: None.

HAMMARSHAGEHÄLLAR 1, *Sundre Beds*, middle part. Pockets of brownish- to reddish-grey marl in dense crinoidal limestone. G 73-69 KL. Tentaculitids: None.

HAMMARSHAGEHÄLLAR 2, 631521 165215 (CJ 3610 1397), ca. 4175 m SSW of Hamra church. Topographical map sheet 5I Hoburgen SO & 5J Hemse SV. Geological map sheet Aa 152 Burgsvik.

The westernmost part of the sea stack area at Hammarshagehällar. The locality is ca. 125 m N of the small point on the NE shore of Skvalpvik, at the westernmost small sea stacks. For a photograph of the locality, see Fig. 76, Munthe (1921b): Hammarshagehällar 2 is on the left side and 7 cm from the lower edge of the photograph

Sundre Beds. Pockets of brownish-grey marl in dense crinoidal limestone. G 72-74 KL. Tentaculitids: *Odessites* sp. Gen. et sp. indet.

References: Munthe 1921a, Fig. 52, p. 25, bottom seventeen lines, p. 26, lines 1-10 (references to the area in general); Munthe 1921b, Fig. 76, p. 140, lines 9-24 (reference to the area in general); Manten 1971, p. 5, line 11, p. 42, line 1, p. 179, line 10, p. 189, lines 9-10 from the bottom, p. 208, line 2 from bottom, p. 418, last line.

HAMMARUDDEN 1, *Hemse Beds*, unit *c*. Intercalations of grey to brownish-grey marl in fine grained limestone. MS 9, 124, 136, 141, 183, 188, 196, 198, 254. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites geretiensis*, *Podolites paeninsulicola*.

HÄRDARVE 1, *Eke Beds*, upper part. Brownish-grey marl and silty, argillaceous limestone. MS 762. Tentaculitids: *Lonchidium ogmotum*.

HAUGKLINTAR 1, *Mulde Beds*, upper part. Brownish-grey marl and fine grained, argillaceous limestone. G 75-15 KL. Tentaculitids: *Alternatus?* sp., *Volynites muldiensis*.

HAVDHEM 1, 634035 165320 (CJ 3905 3894), ca. 875 m E of Havdem church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.

Former railway section ca. 200 m N of point 27.15. The locality is shown in Munthe 1921b, Fig. 20 (=Munthe *et al.* 1925, Fig. 6).

Eke Beds. Brownish-grey, silty and micaceous marl rich in algae. MS 751. Tentaculitids: *Dicricoconus* sp., *Odessites prolatus*.

References: Munthe 1921b, Fig. 20; Munthe *et al.* 1925, Fig. 6.

HEMSEENKLAVEN 1, 635654 164772 (CJ 3482 5550), ca. 3250 m NNW of Levide church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 164 Hemse.

Former railway section, ca. 500 m NW of point 43.30 at Magnuse.

Klinteberg Beds, lower-middle part. Intercalations of grey marl in dense, fine grained limestone. MS 629. Tentaculitids: None.

HERRGÅRDSKLINT 1, *Hemse Beds*, Millklint Limestone. Intercalations of greenish-grey marl in dense limestone rich in stromatoporoids and crinoids. MS 871. Tentaculitids: *Odessites inflatus*.

HERRVIDE 1, *Eke Beds*, lower-middle part. Brownish-grey, silty marl rich in algae. MS 340. Tentaculitids: *Odessites prolatus*.

HERRVIK 1, *Hemse Beds*, unit *d*. Intercalations of brownish-grey marl in dense, argillaceous limestone. MS 842. Tentaculitids: None

HIDE 1, *Slite Beds*, Slite Marl. Brownish- and bluish-grey marl and argillaceous limestone. MS 110,160, 170, 249, 652. Tentaculitids: *Alternatus?* sp., *Turmalites slitiensis*.

HIDE FISKELÄGE 1, *Slite Beds*, Slite Marl, top. Greenish- and brownish-grey marl and dense, argillaceous limestone. MS 843, 844, 846, 847, 848. Tentaculitids: *Alternatus?* sp., *Turmalites slitiensis*.

HIDE FISKELÄGE 2, *Slite Beds*, unit *g*. Intercalations of greenish-grey marl in dense, argillaceous limestone. MS 845. Tentaculitids: None.

HOBURGEN 1, *Hamra Beds*, unit *c*. Brownish-grey marlstone. G 730710 CF. Tentaculitids: *Odessites majstriensis*.

HOBURGEN 2, *Burgsvik Beds*, uppermost part. Grey marly siltstone with intercalations of calcareous shale. G 73-20 KL, -21 KL. Tentaculitids: *Alternatus?* sp., *Tentaculites hisingeri*. Yellowish grey, argillaceous oolite. G 73-19 KL, -22 KL. Tentaculitids: *Lonchidium scanicum*?, *Odessites portensis*, *Tentaculites hisingeri*.

Hamra Beds, unit *b*. Pockets of brownish- and greenish-grey marl in dense, argillaceous limestone. MS 494, 566, G 72-37 KL, G 73-23 KL. Tentaculitids: *Alternatus?* sp., *Odessites majstriensis*, *Tentaculites hisingeri*.

HOBURGEN 3, *Hamra Beds*, unit *c*. Intercalations of light brownish-grey marl in coarse grained crinoidal limestone rich in stromatoporoids. MS 31, 220, 232. Tentaculitids: None.

HOBURGEN 4, *Hamra Beds*, unit *c*, upper part. Pockets of brownish-grey marl in coarse grained crinoidal limestone. MS 2, 49, 240, 272, 280, 285. Tentaculitids: *Alternatus?* sp., *Dicricoconus?* sp., *Odessites majstriensis*.

HOLMHÄLLAR 1, *Sundre Beds*, middle part. Fissure fillings of green and greenish-grey marl in dense limestone rich in crinoids and stromatoporoids. MS 905. Tentaculitids: *Odessites* spp., *Lonchidium* sp.

HORSAN 1, 641966 167848 (CK 7030 1605), ca. 3825 m W of Fleringe church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shore section 200 m NW of the old lime kiln, ca. 275 m WSW of the triangulation point at Horsan.

Reference level: The boundary between Hede's local units *b* and *c*.

Högklint Beds, unit *b* (Hede's local units *a*, *b* and *c*). Light grey and brown marl, marlstone and argillaceous limestone. G 73-26, -27, G 74-49, -50, -51 (all KL). Tentaculitids: *Tentaculites limatulus*?, *T. liquis*, *Turmalites follingboensis*.

References: Hede 1933, p. 20, bottom twelve lines, p. 21, lines 1-11 (contains list of fossils from a measured section).

HÖRSNE 1, *Halla Beds*, unit *b*. Brownish-grey to brown marl and calcareous mudstone. MS 103, 478, 479, 480, 483, 894. Tentaculitids: *Alternatus?* sp., *Dicricoconus cracens*.

HÖRSNE 2, *Halla Beds*, unit *b*. Brownish-grey marl and calcareous mudstone. MS 561, 653. Tentaculitids: None.

HÖRSNE 6, 638420 166700 (CJ 5620 8218), ca. 150 m SW of Hörsne church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Southern wall of the drainage ditch section immediately W of locality Hörsne 2. Hörsne 6 comprises the distance 70-150 m W of the bridge. For a detailed description, see Hede 1928.

Halla Beds, unit *b*. Greyish-brown marl. G 74-37 KL, -38 KL, -39 KL, G 75-54 KL, Got 74-37 SB. Tentaculitids: *Alternatus?* spp.

References: Hede 1928, p. 50, bottom five lines - p. 51, line 35 (contains lists of fossils); the ditch has been widened since Hede's description was written.

HULTE 1, *Hemse Beds*, Hemse Marl, southeastern part. Light bluish-grey marl. MS 1, 55, 73, 217, 228, 290, 292. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

HUMMELBOSHOLM 2, 634434 166665 (CJ 5276 4190), ca. 7475 m ESE of Rone church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.

Shore exposure on the southern side of the peninsula, ca. 375 m S of the triangulation point at Hummelbosholm. The locality is reached by following the field road marked on the topographical map to a gate at the end, then along the fence SE to the shore.

Eke Beds. Brownish-grey, calcareous, silty shale rich in algae; bluish-grey silty shale; brownish- and bluish-grey silty, argillaceous limestone. G 72-82 KL, -83 KL, -84 KL. Tentaculitids: *Odessites prolatus*, *Tentaculites hisingeri*, *T. obstipus*.

HUNNINGE 1, *Klinteberg Beds*, lower-middle part. Intercalations of greenish-grey marl in dense crinoidal limestone. MS 8, 36, 45, 146, 157, 164, 167, 168, 347, 472, 475, 475, 477, 657, 861, G 72-20 KL, -21 KL, G 73-76 KL, -77 KL, Got 75-3 SB. Tentaculitids: *Alternatus?* spp.

HUSRYGGEN 2, 631545 164272 (CJ 2665 1492), ca. 2100 m NW of Sundre church. Topographical map sheet 5I Hoburgen SO & 5J Hemse SV. Geological map sheet Aa 152 Burgsvik.

Quarry 10-20 m W of the road, from ca. 50 m NNE of Husryggen 1.

Reference level: The Burgsvik-Hamra boundary.

Burgsvik Beds, uppermost part. Grey silty marl and silty, calcareous shale. MS 21, 44, 112, 206, 422, 824, 825, 826. Tentaculitids: *Odessites portensis*, *Tentaculites hisingeri*.

References: Martinsson 1962, p. 58 (Husryggen).

HUSRYGGEN 3, 631563 164287 (CJ 2689 1510), ca. 2020 m NW of Sundre church. Topographical map sheet 5I Hoburgen SO & 5J Hemse SV. Geological map sheet Aa 152 Burgsvik.

Surface exposure on the northernmost part of the crest of Husryggen.

Hamra Beds, unit *b*. Brownish-grey marl and argillaceous limestone. MS 772. Tentaculitids: *Odessites majstriensis*, *Tentaculites hisingeri*

IREVIKEN 1, *Upper Visby Beds*. Grey to brownish-grey marl and argillaceous limestone. MS 13, 288. Tentaculitids: *Gotlandellites areolatus*, *Seretites? cataractae*.

IREVIKEN 2, *Lower Visby Beds*, top. Bluish-grey marl and marlstone. G 74-47 KL. Tentaculitids: *Alternatus?* sp., *Gotlandellites visbyensis*, *Seretites? exilis*.

Upper Visby Beds. Bluish- and brownish-grey marl and argillaceous limestone. G 74-48 KL Tentaculitids: *Gotlandellites areolatus*, *Seretites? exilis*.

Högklint Beds. Pockets of grey to brownish-grey marl in reef limestone. MS 12, 93, 140, 184, 345, 386, 548. Tentaculitids: None.

IREVIKEN 3, *Lower Visby Beds*, top. Bluish-grey marl and marlstone. MS 607, G 72-14 KL, G 74-58 KL. Tentaculitids: *Gotlandellites visbyensis*, *Seretites? exilis*.

JAKOBS 1, *Hemse Beds*, Hemse Marl, uppermost part. Greenish-grey, calcareous, silty mudstone. G 75-22 KL. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*?.

JAKOBSBERG 1, *Slite Beds*, unit *g*. Pockets of brown marl in fine grained, slightly argillaceous limestone. G 72-38 KL. Tentaculitids: None.

JÄNNKLINT 1, 642510 167126 (CK 6353 2203), ca. 2950 m N of Hall church. Topographical map sheet 7J Fårösund SV & NV. Geological map sheet Aa 171 Kappelshamn.

Inland cliff section immediately SE of the road, ca. 60 m NNW of the ancient monument at Jännklinten.

Högklint Beds, unit *b*. Light bluish-grey marl in fine grained, argillaceous limestone. G 73-37 KL. Tentaculitids: None.

References: Manten 1971, pp. 71, 119, Fig. 35, pp. 122, 126, 155, Fig. 62, pp. 159, 161, 281, 284, 302, 305, Fig. 156.

JUVES 1, *Hamra Beds*, unit *c*. Light brownish-grey marl and fine grained, silty and argillaceous limestone. Got 74-34 SB. Tentaculitids: *Odessites majstriensis*.

JUVES 2, *Hamra Beds*, unit *c*, top. Intercalations of light brownish-grey marl in coarse grained, crinoidal limestone. MS 493, G 73-24 KL. Tentaculitids: *Alternatus?* sp.

JUVES 3, *Hamra Beds*, top. Intercalations of grey to brownish-grey marl in medium grained limestone. MS 84, 281, 452, 453. Tentaculitids: *Odessites majstriensis*.

JUVES 4, *Sundre Beds*, lower part. Pockets of light brownish-grey marl in limestone. MS 705, 706, 731. Tentaculitids: *Odessites majstriensis*.

KALLGATE 1, 639810 167120 (CJ 6140 9513), ca. 2650 m ESE of Hejnum church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Inland cliff section ca. 375 m N of the easternmost junction of the field roads W of Kallgate, ca. 1800 m NW of the triangulation point at Graute.

Slite Beds, middle part. Pockets of brownish-grey marl in coarse grained, conglomeratic limestone. MS 733, 734, 735. Tentaculitids: None.

KAMBS 3, *Tofta Beds*. Greenish-grey, strongly argillaceous limestone rich in algae and stromatoporoids. G 72-50 KL. Tentaculitids: None.

KAPELLET, 634746 167132 (CJ 5765 4465), ca. 8500 m ESE of Burs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.

Shore exposure on the eastern shore of Pilgårdsvik, ca. 125 m NNW of the northernmost house at Kapellet.

Burgsvik Beds. Yellowish-grey, coarse grained limestone, rich in crinoids. G 72-78 KL. Tentaculitids: None.

References: Hede 1925b, p. 32 bottom eight lines, p. 33, lines 1-12 (contains list of fossils).

KAPPELSHAMN 1, *Högklint Beds*, unit *b*. Light grey marlstone and fine grained, argillaceous limestone. G 72-44 KL. Tentaculitids: *Alternatus?* sp., *Tentaculites limatulus*, *T. liquis*.

KAPPELSHAMN 2, *Högklint Beds*, unit *b*. Light grey marlstone and fine grained, argillaceous limestone. G 72-43 KL. Tentaculitids: *Tentaculites liquis*.

KÄRNE 1, *Burgsvik Beds*, upper part. Pockets of greenish-grey marl in argillaceous crinoidal limestone. MS 599. Tentaculitids: None.

KARNE 2, 634791 166623 (CJ 5262 4549), ca. 3625 m SE of Burs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 156 Ronehamn.

Cliff section immediately SW of the westernmost windmill at Kärne.

Burgsvik Beds, upper part. Greenish-grey, coarse grained, slightly argillaceous crinoidal limestone. G 72-66 KL. Tentaculitids: None.

KARTHAKEN 1, 640971 169219 (CK 8320 0509), ca. 1625 m E of the triangulation point at Furilden. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shore section at the point at Karthaken, on the eastern shore of Furilden.

Slite Beds, unit *g*. Intercalations of greenish-grey marl in fine grained, dense limestone rich in stromatoporoids. SMNH (unnumbered sample). Tentaculitids: *Alternatus?* sp., *Tentaculites* cf. *gothemensis*.

KÄTTELVIKEN 1, *Burgsvik Beds*, upper part. Bluish-grey marl and marlstone. G 73-70 KL. Tentaculitids: *Alternatus?* sp.

Hamra Beds, unit *a*. Light greyish-brown, silty and argillaceous limestone rich in algae. MS 796. Tentaculitids: *Alternatus?* sp.

KÄTTELVIKEN 3, *Hamra Beds*. Brownish-grey marl and marlstone. Got 76-42 SB. Tentaculitids: *Alternatus?* sp.

KÄTTELVIKEN 4, *Hamra Beds*, unit *b*. Brownish-grey marl and argillaceous limestone MS 778. Tentaculitids: *Alternatus?* sp., *Dicricoconus?* sp., *Odessites majstriensis*, *Tentaculites hisingeri*.

KÄTTELVIKEN 5, *Hamra Beds*, unit *b*. Light bluish-grey marl and marlstone. G 75-20 KL. Tentaculitids: *Tentaculites hisingeri*.

KAUPUNGS 1, *Hemse Beds*, unit *e*, lower part. Pockets of brownish- and greenish-grey marl in medium limestone. MS 189, 866. Tentaculitids: None.

KLASENBORRNINGEN 1, 633579 165898 (CJ 4447 3396), ca. 5275 m ESE of Grötlingbo church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Temporary excavation immediately E of the intersection of the field roads 250 m S of the houses at Klasen. The excavation formed the mudpit for the OPAB borehole Klasen 1.

Burgsvik Beds. Grey to greyish-white, marly sandstone. G 73-82 KL. Tentaculitids: *Lonchidium scanicum*, *Odessites portensis*, *Tentaculites hisingeri*.

KLINTEBERGET 1, *Klinteberg Beds*, lower-middle part. Pockets of greenish- and brownish-grey marl in dense limestone. MS 570, 571, 572, 573, 574, 867, G 72-23 KL. Tentaculitids: *Alternatus?* sp., *Podolites hedei*, *Tentaculites gothemensis*?.

KLINTEBYS 1, *Slite Beds*, Slite Siltstone, top. Grey, calcareous and argillaceous siltstone. G 74-42 KL. Tentaculitids: None.

KLINTEBYS 2, *Mulde Beds*. Brownish-grey marl. MS 488. Tentaculitids: *Alternatus?* sp., *Volynites muldiensis*.

KLINTSBROVIK 1, 642341 169351 (CK 8557 1864), ca. 4600 m SE of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Large abandoned quarry on the southwestern shore of Fårö Island, ca. 425 m NE of the pier at Hagarsbajnsriv. The quarry is marked on the topographical map.

Reference point: The entrance of the quarry.

Slite Beds, Kalbjerga Limestone. Intercalation of greenish-grey marl in dense, fine grained limestone. G 73-16 KL. Tentaculitids: None.

References: Hede 1936, p. 23, lines 6-8 from the bottom.

KLINTSKLINT 1, *Hemse Beds*, unit *d*. Intercalations of light greenish-grey marl in dense limestone rich in stromatoporoids. MS 753, G 73-28 KL. Tentaculitids: None.

KLOCKAREMYR 1, *Tofta Beds*. Pockets of light greenish-grey marl in dense limestone rich in algae. MS 860. Tentaculitids: None.

KODINGS 1, *Hemse Beds*, Hemse Marl, southeastern part. Light greenish-grey marl and argillaceous limestone. G 75-7 KL. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

KODINGS 2, *Hemse Beds*, Hemse Marl, southeastern part. Light greenish-grey marl and argillaceous limestone. MS 554, 742, G 75-8 KL. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

KODINGS 3, *Hemse Beds*, Hemse Marl, southeastern part. Light greenish-grey marl and argillaceous limestone. G 75-6 KL. Tentaculitids: *Dicricoconus tenuissimus*.

KODINGS 4, 634800 165683 (CJ 4325 4629), ca. 1775 m ESE of Hemse church. Topographical map sheet 5I Hoburgen NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately NE of the sharp bend of the road, ca. 825 m WSW of Lindvide.
Hemse Beds, Hemse Marl, southeastern part. Light greenish-grey marl and argillaceous limestone. MS 732. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

KODINGS 5, 634821 165686 (CJ 4330 4650), ca. 1825 m E of Hemse church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section at the sharp bend of the ditch, ca. 725 m WSW of Lindvide.
Hemse Beds, Hemse Marl, southeastern part. Light greenish-grey marl and argillaceous limestone. MS 726. Tentaculitids: *Dicricoconus tenuissimus*.

KOPPARSVIK 1, 639210 164772 (CJ 3754 9095), ca. 1825 m SW of Visby cathedral. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.
Cliff section in the SE part of the abandoned marl pit (Lergraven) of the former Visby Cementfabrik, ca. 190 m S of the oil storage tanks at Färjeleden (not marked on the topographical map).
Note. The marl pit has now been completely filled in and now only the eastern wall of the pit is accessible.
Upper Visby Beds. Greenish-grey marl, marlstone and argillaceous limestone. G 74-8 KL. Tentaculitids: *Alternatus*? sp., *Gotlandellites areolatus*, *Seretites*? *exilis*.
References: Hede 1921, p. 28, lines 9-10; Hedström 1923b, Fig. 1; Hede 1925a, Fig. 11, p. 36, lines 12-14 from the bottom; Hede 1940, p. 13, lines 1-2.

KORPKLINT 1, *Högklint Beds*, unit *a*. Pockets of brownish-grey marl in medium grained, slightly argillaceous limestone. G 72-1 KL, G 73-87 KL. Tentaculitids: None.

KULLANDS 1, *Hemse Beds*, Hemse Marl, northwestern part. Greenish- and brownish-grey marl and argillaceous limestone. MS 689, 865, 71 G 4 AM, G 74-31 KL. Tentaculitids: *Odessites geretiensis*?.

KULLUNDE 2, *Eke Beds*, middle-upper part. Grey to brownish-grey marl and fine grained, argillaceous, algal limestone. MS 863, 873, G 72-32 KL. Tentaculitids: *Odessites prolatus*, *Tentaculites obstipus*.

KULLUNDE 3, 634060 165796 (CJ 4380 3881), ca. 2330 m ESE of Eke church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately NE of the field road, ca. 90 m NW of the crossroads (marked on the topographical map sheet) which have the sign "Kulturminne".
Eke Beds. Grey to brownish-grey marl. Got 76-28 SB, -30 SB, -31 SB. Tentaculitids: *Odessites prolatus*, *Tentaculites obstipus*.

KULLUNDE 4, 634050 165816 (CJ 4398 3871), ca. 2480 m ESE of Eke church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately N of the field road, ca. 100 m E of the crossroads (marked on the topographical map sheet) which have the sign "Kulturminne".
Eke Beds. Greenish- and brownish-grey marl. Got 76-33 SB. Tentaculitids: *Odessites portensis*, *Odessites prolatus*, *Tentaculites obstipus*.

KULLUNDE 5, 634054 165835 (CJ 4421 3873), ca. 2700 m ESE of Eke church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately N of the field road, ca. 350 m E of the crossroads (marked on the topographical map sheet) which have the sign "Kulturminne".
Eke Beds. Brownish- and greenish-grey marl. Got 76-34 SB. Tentaculitids: *Odessites portensis*?, *Odessites prolatus*, *Tentaculites obstipus*.

KULLUNDE 6, 634054 165859 (CJ 4446 3871), ca. 2950 m ESE of Eke church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately N of the field road, ca. 600 m from the crossroads (marked on the topographical map sheet) which have the sign "Kulturminne".
Eke Beds. Greenish- and brownish-grey marl. Got 76-35 SB. Tentaculitids: *Odessites portensis*?, *Odessites prolatus*, *Tentaculites obstipus*.

KULLUNDE 7, 634014 165916 (CJ 4498 3828), ca. 3550 m ESE of Eke church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately NE of the field road, ca. 1300 m from the crossroads (marked on the topographical map sheet) which have the sign "Kulturminne".
Eke Beds. Brownish- and greenish-grey marl. Got 76-36 SB. Tentaculitids: *Odessites portensis*?, *Odessites prolatus*, *Tentaculites obstipus*.

KULLUNDE 8, 633987 165953 (CJ 4532 3798), ca. 3980 m ESE of Eke church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately NE of the field road, ca. 1800 m from the crossroads (marked on the topographical map sheet) which has the sign "Kulturminne". The locality is situated at a crossroads where a small field road (not marked on the topographical map sheet) runs south.
Eke Beds. Brownish- and greenish-grey marl. Got 76-37 SB. Tentaculitids: *Odessites prolatus*, *Tentaculites obstipus*.

KJPPEN 1, *Hemse Beds*, unit *d*. Intercalations of greenish- and brownish-grey marl in coarse grained limestone. MS 818. Tentaculitids: None.

KUTÅRD 1, 632853 164639 (CJ 3137 2768), ca. 6200 m SSW of Näs church. Topographical map sheet 5J Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.
Low shore exposure on the secondmost southern point of Näsudden, ca. 675 m W of Tvärård. There is a field road (not marked on the topographical map) from the crossroads SE of the triangulation point Skåls running SE to a solitary house, and the locality lies further in the same direction over the field.
Eke Beds, lower-middle part. Grey, silty marlstone. G 73-96 KL. Tentaculitids: None.

KVÄNNVATEN 1, *Slite Beds*, *Pentamerus gotlandicus* Beds. Pockets of greenish-grey marl in medium grained limestone. G 72-107 KL, G 73-61 KL. Tentaculitids: None.

KVARNBERGET 1, *Slite Beds*, Slite Marl, uppermost part. Brownish- and greenish-grey marl, marlstone and argillaceous limestone. MS 495, 694, 695, 697, G 74-59 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *D. gutnicus*, *Turmalites slitiensis*.
Slite Beds, unit *g*. Pockets of greenish-grey marl in medium grained limestone. MS 696. Tentaculitids: None.

KYLLAJ 1, *Slite Beds*, unit *g*. Pockets of brownish-grey marl in coarse grained limestone. MS 299. Tentaculitids: None

LAMBSKVIE 1, *Hemse Beds*, unit *c*. Brownish- and greenish-grey marl and dense, argillaceous limestone. G 74-62 KL, Got 74-3 SB, -17 SB. Tentaculitids: *Alternatus*? spp.

LANGARS 1, *Slite Beds*, Slite Marl. Brownish- and greenish- grey marl and argillaceous limestone. MS 190, 424. Tentaculitids: *Turmalites slitiensis*.

LANGS HAGE 1, 638877 164902 (CJ 3858 8752), ca. 3600 m NE of Västerhejde church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.
Abandoned quarry immediately SE of the road, ca. 150 m SW of the crossroads SW of the ancient monument at Langs Hage. The quarry is the southwesternmost one marked on the geological map.
Slite Beds, Kalbjerga Limestone. Greenish-grey, strongly argillaceous limestone. MS 799, 800. Tentaculitids: None.
References: Hede 1940, p. 50, lines 6-9 (reference to the area in general).

LANSA 1, *Slite Beds*, unit *d*. Intercalations of yellowish- and greyish-brown marl in medium grained limestone. MS 682. Tentaculitids: None.

LAU BACKAR 1, *Eke Beds*, *Rhizophyllum* Limestone, upper part. Light greenish-grey, calcareous mudstone, brownish-grey marl and fine grained, argillaceous limestone. MS 16, 19, 40, 51, 88, 211, 212, 215, 227, 234, 241, 395, 408, 409, 410, 455, 456, 457, 490, 563, 794, G 72-27 KL, G 74-65 KL, Got 74-20 SB. Tentaculitids: *Alternatus*? spp., *Lonchidium scanicum*, *Odessites* [illegible]

LAUSVIK 1, *Hemse Beds*, Hemse Marl, upper part. Grey, calcareous, shaly mudstone and argillaceous limestone. MS 851, G 74-27 KL. Tentaculitids: *Odessites inflatus*.

LAUTERHORNSVIK 3, 643051 169433 (CK 8693 2565), ca. 5250 m NW of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.
Ditch section immediately S of the ditch and road intersection, ca. 650 m NNE of the triangulation point at Lauterhorn.
Högklint Beds, lower-middle part. Yellowish-grey, slightly argillaceous, medium grained limestone. G 73-11 KL. Tentaculitids: *Tentaculites liquis*, *Tentaculites* sp.
References: Hede 1936, p. 14, bottom twenty-two lines, p. 15, lines 1-2 (contains list of fossils).

LEISUNGS 1, *Hemse Beds*, Hemse Marl, southeastern part top. Greenish-grey marl and calcareous mudstone. MS 294, 342, 703, 704, 717. Tentaculitids: *Dicricoconus tenuissimus*.

LERBERGET 1, *Slite Beds*, Slite Marl, Lerberget Marl, lower part. Brownish-grey marl and argillaceous limestone. MS 390, 425. Tentaculitids: None.

LICKERSHAMN 1, *Lower Visby Beds*, top. Bluish-grey marl and marlstone. G 72-9 KL, -10 KL. Tentaculitids: *Alternatus*? sp., *Gotlandellites visbyensis*.
Upper Visby Beds. Bluish- and greenish-grey marl, marlstone and argillaceous limestone. MS 305, G 72-11 KL. Tentaculitids: *Seretites*? *exilis*.
Högklint Beds, unit *a*. Pockets of greenish-grey marl in coarse grained limestone. G 72-12 KL, -13 KL. Tentaculitids: None.

LICKERSHAMN 2, *Upper Visby Beds*. Greenish-grey marl and argillaceous limestone. G 74-43 KL, -44 KL. Tentaculitids: *Alternatus*? sp.
Högklint Beds. Intercalations of brownish- and greenish-grey marl in dense limestone. MS 126, 331, 324, G 74-45 KL, -46 KL. Tentaculitids: *Alternatus*? sp., *Seretites*? *cataractae*.

LIFFRIDETRASK 1, 635743 166049 (CJ 4762 5541), ca. 3500 m N of Stånga church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 164 Hemse.
Inland cliff section on the southern shore of Liffridetrask.
Hemse Beds. Pockets of greenish- and brownish-grey marl in reef limestone. MS 750. Tentaculitids: None.

LILLA HALLVARDS 1, *Hemse Beds*, Hemse Marl, northwestern part. Grey marl and argillaceous limestone. MS 122, 225. Tentaculitids: None.

LILLA HALLVARDS 2, *Hemse Beds*, Hemse Marl, northwestern part. Bluish-grey marl and calcareous shale. G 72-86 KL, -87 KL. Tentaculitids: *Dicricoconus* sp.

LILLA HALLVARDS 3, 634221 164436 (CJ 3038 4147), ca. 4250 m WSW of Hablingbo church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Surface exposure 30 m N of the road, ca. 1000 m ENE of the crossroads S Lilla Hallvards. A small track runs from the road between the telephone poles numbered 52 and 53.
Hemse Beds, Hemse Marl, northwestern part. Bluish-grey calcareous shale and marl. G 72-85 KL. Tentaculitids: *Dicricoconus tenuissimus*.

LILLA HALLVARDS 4, 634171 164281 (CJ 2879 4109), ca. 5840 m WSW of Hablingbo church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch excavation crossing field road and continuing ca. 120 m SE from the road.
Reference point: The intersection of ditch and road.
Hemse Beds, Hemse Marl, northwestern part. Bluish-grey marl and calcareous shale. Got 76-32 SB. Tentaculitids: *Dicricoconus tenuissimus*?.

LILLA RINGUME 1, 634717 165421 (CJ 4058 4567), ca. 1250 m SW of Hemse church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section immediately N of the road at the road and powerline intersection.
Hemse Beds, Hemse Marl. Greenish- and bluish-grey marl and marlstone. MS 757, 758. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites inflatus*.

LILLA SNÖGRINDE 1, *Klinteberg Beds*, lower-middle part. Pockets of greenish-grey marl in dense limestone. MS 614, 615, 616, 617, G 72-22 KL. Tentaculitids: None.

LINDE 1, *Hemse Beds*, upper part. Pockets of light brownish-grey marl in coarse grained, crinoidal limestone. MS 154, 560, 664, 665, 699. Tentaculitids: *Alternatus*? sp., *Odessites geretiensis*.

LINE 1, 638392 166789 (CJ 5702 8125), ca. 1250 m SE of Hörsne church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.
Low road section 175 m NW of point 21.52 at Line. The locality is immediately NE of the quarry marked on the topographical map sheet.
Klinteberg Beds, lower-middle part. Pockets of greenish-grey marl in reef limestone. G 72-100 KL. Tentaculitids: None.

LINGVIDE 1, *Eke Beds*, lower part. Brownish-grey marl and argillaceous limestone. MS 6, 57, 307, 312, 330, 334, 335, 556. Tentaculitids: *Odessites prolatus*, *Tentaculites obstipus*

LINVIKEN 1, 633494 164607 (CJ 3153 3409), ca. 2875 m WNW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.
Low shore exposure on the northern shore of Linviken, ca. 825 m SE of the house at Grundården.
Hemse Beds, Hemse Marl, uppermost part. Bluish-grey marl, marlstone and argillaceous limestone. G 72-89 KL. Tentaculitids: *Dicricoconus tenuissimus*
References: Hede 1919a, Locality 6, p. 17, bottom seven lines, p. 18, p. 19, lines 1-10 (contains list of fossils); Hede 1942, p. 20, locality 4c, Fig. 2.

LUKSE 1, *Hemse Beds*, Hemse Marl, northwestern part. Grey marl and argillaceous limestone. MS 81, 204, 302, 496, 660. Tentaculitids: *Alternatus*? sp., *Dicricoconus tenuissimus*, *Odessites geretiensis*.

LUNDE 1, *Burgsvik Beds*, uppermost part. Yellowish-grey oolitic limestone. SMNH (unnumbered samples). Tentaculitids: *Tentaculites hisingeri*.

MAGNUSE 1, 638765 167482 (CJ 6421 8444), ca. 675 m NW of Gothem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.
Shallow ditch exposure immediately NE of the road, ca. 160 m NW of the crossroads at Magnuse.
Klinteberg Beds, unit *b*. Pockets of brownish-grey marl in dense, fine grained limestone. MS 622. Tentaculitids: None.

MAJSTRE 1, 631335 164176 (CJ 2560 1290), ca. 3175 m WSW of Sundre church. Topographical map sheet 5I Hoburgen SO & 5J Hemse SV. Geological map sheet Aa 152 Burgsvik.
Drainage ditch section 50 m E of the road, ca. 325 m NNW of the crossroads NE of Hoburgen. The locality is apparent as a notch in the rise east of the road.
Hamra Beds, unit *b*. Light brownish-grey, calcareous marlstone and argillaceous limestone. MS 775, G 73-71 KL, Got 75-2 CB. Tentaculitids: *Alternatus*? sp., *Odessites majstriensis*, *Tentaculites hisingeri*.

MALMS 1, *Hemse Beds*, Hemse Marl, southeastern part, top. Light yellowish- and greenish-grey marl and marlstone. G 74-22 KL, -23 KL. Tentaculitids: *Odessites inflatus*, *Tentaculites* sp.

MEDBYS 1, *Hemse Beds*, middle part? Intercalations of greenish-grey marl in dense limestone rich in stromatoporoids. MS 105, 339, 396, 397, 398. Tentaculitids: *Dicricoconus tenuissimus*.

MILLKLINT 1, *Hemse Beds*, Millklint Limestone. Intercalations of brownish-grey marl in fine grained limestone. MS 279, 674, 675. Tentaculitids: *Odessites* [illegible].

MILLKLINTDALEN 1, *Hemse Beds*, Millklint Limestone. Intercalations of brownish-grey marl in fine grained limestone. MS 673. Tentaculitids: None.

MOJNER 1, 639918 167668 (CJ 6694 9578), ca. 525 m SSE of Boge church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.
Ditch section NE of the road, ca. 200 m N of the crossroads S of Boge.
Slite Beds, Slite Marl. Brownish-grey marl and calcareous mudstone. MS 686, 755. Tentaculitids: *Dicricoconus gutnicus*, *Turmalites slitiensis*.

MOJNER 2, 639941 167915 (CJ 6942 9582), ca. 2575 m E of Boge church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.
Shore section ca. 750 m SE of point 3.70 SE of Bogeviken, ca. 200 m S of the military installations.
Slite Beds, Slite Marl. Brownish-grey, calcareous, slightly silty mudstone. G 73-42 KL. Tentaculitids: None.

MÖLLBOS 1, *Halla Beds*, unit *b*. Brownish-grey marl and argillaceous limestone. MS 444. Tentaculitids: None.

MÖLLBOS 2, *Halla Beds*, unit *b*. Pockets of brownish- and greenish-grey marl in fine grained, stromatoporoid limestone. Got 74-7 SB. Tentaculitids: *Alternatus*? spp.

MÖLNER 1, *Mulde Beds*, Upper part. Light brownish-grey marl and argillaceous limestone. MS 679, 716, 745, 746, G 74-40 KL. Tentaculitids: *Alternatus*? sp., *Volynites muldensis*.

MULDE 1, *Slite Beds*, Slite Siltstone. Yellowish- and greyish-brown, silty and argillaceous limestone. G 75-14 KL. Tentaculitids: *Alternatus* sp.

MULDE TEGELBRUK 1, *Mulde Beds*, lower-middle part. Brownish- and bluish-grey marl and marlstone. MS 10 (23 different samples), 421, 608, 643, 648, 655, 765 A-K, 798, SMNH (several unnumbered samples). Tentaculitids: *Alternatus*? spp., *Dicricoconus cracens*, *Volynites scalpratus*, *V. muldiensis*.

MYRSE 1, 638195 164813 (CJ 3717 8079), ca. 1200 m SE of Stenkumla church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 160 Klintehamn.
Ditch section immediately N of the ditch and road intersection, ca. 175 m WNW of the northwesternmost house at Myrse.
Slite Beds, Slite Marl. Greenish- and brownish-grey marl and marlstone. G 73-60 KL. Tentaculitids: *Dicricoconus gutnicus*, *Turmalites follingboensis*.

NABBAN 1, *Eke Beds*, lower part. Grey, coarse grained, slightly argillaceous limestone rich in bryozoans and crinoids. G 72-52 KL, -53 KL. Tentaculitids: None.

NÄRS FYR 2, *Hamra Beds*, lower part. Light brownish-grey, coarse grained limestone rich in crinoids and stromatoporoids. G 73-52 KL. Tentaculitids: None.

NÄS 1, *Eke Beds*, lower part. Brownish-grey, silty marl rich in algae. MS 747, G 72-98 KL. Tentaculitids: None.

NISSE 1, *Hemse Beds*, Hemse Marl, nortwestern part. Grey marl and argillaceous limestone. MS 754. Tentaculitids: *Dicricoconus tenuissimus*.

NISSE 2, 633840 164840 (CJ 3268 3748), ca. 4700 m SSW of Hablingbo church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.
Ditch exposure immediately S of the road, ca. 350 m E of the crossroads E of Nisse.
Hemse Beds, Hemse Marl, northwestern part. Greenish-grey marl. G 73-100 KL, Got 76-49 SB. Tentaculitids: *Dicricoconus tenuissimus*?, *Odessites geretiensis*?.

NISSE 3, 633856 164749 (CJ 3323 3759), ca. 4400 m SSW of Hablingbo church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.
Ditch exposure immediately S of the road, ca. 925 m E of the crossroads E of Nisse.
Hemse Beds, Hemse Marl, northwestern part. Bluish-grey marl and marlstone. G 73-93 KL. Tentaculitids: *Dicricoconus tenuissimus*.

NORRBYS 1, *Slite Beds*, unit *g*. Pockets of brownish-grey marl in coarse grained limestone rich in bryozoans and stromatoporoids. MS 418, 436, 437, 438. Tentaculitids: *Dicricoconus acutalis*?, *Turmalites follingboensis*, *T. slitiensis*?.

NYAN 1, *Eke Beds*, lower part. Grey, coarse grained, slightly argillaceous limestone rich in bryozoans and crinoids. G 72-54 KL. Tentaculitids: None.

NYAN 2, *Hemse Beds*, Hemse Marl, *Dayia* Flags. Light grey, calcareous, micaceous and argillaceous siltstone. G 72-55, -56, -57, -58, all KL, G 73-50 KL. Tentaculitids: *Odessites inflatus*.
Eke Beds, lowermost part. Brownish-grey, slightly silty and argillaceous limestone. G 72-59 KL, -60. Tentaculitids: None.

NYAN 3, 634915 253794 (CJ 6035 4960), ca. 3650 m ENE När church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 156 Ronehamn.
Ditch section immediately south of the road between Bomunds i Hammar and Nabban, ca. 375 m ENE of the cross-roads immediately east of Bomunds i Hammar.
Hemse Beds, uppermost part. Bluish grey marlstone. Unnumbered SGU sample. Tentaculitids: *Odessites inflatus*.

NYGÅRDS 1, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Grey marl and dense, argillaceous limestone. MS 191, 201, G 74-17 KL, Got 76-48 SB. Tentaculitids: *Dicricoconus acutalis*, *D. gutnicus*?, *D. valliensis*.

NYGÅRDS 3, 638207 166139 (CJ 5040 7990), ca. 2825 m SW of Dalhem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 160 Klintehamn.
Section along the Dalhem rivulet, 425 m W of the rivulet and road intersection at Nygårds. Nygårds 3 comprises the section 0-100 m E of the reference point.
Reference point: The northernmost part of the wide bend of the rivulet, 425 m W of the bridge at Nygårds.
Slite Beds, Slite Marl. Bluish-grey marl with intercalations of dense, argillaceous limestone. G 74-16 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus acutalis*, *D. gutnicus*?, *D. svarvariensis*, *D. valliensis*.

NYHAMN 1, *Lower Visby Beds*. Light grey to greenish-grey marl and nodules of argillaceous limestone. MS 17, 71, 78, 101, 176, 178, 182, 246, 391 s, 468, 469, 470, 571 and 875, G 72-8 KL, G 74-57 KL, Got 74-26 SB. Tentaculitids: *Alternatus*? sp., *Gotlandellites visbyensis*, *Seretites*? *exilis*.

NYHAMN 2, *Lower Visby Beds*. Light grey to greenish-grey marl. MS 173. Tentaculitids: None.

NYHAMN 3, 640711 165526 (CJ 4620 1530), ca. 2600 m SW of Lummelunda church. Topographical map sheet 7J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda.
Low slope with rock weathering out at top of beach west of the field road, from 50 to 75 m SW of the huts at Nyhamn Fiskeläge.
Lower Visby Beds. Light grey marl and nodules of dense argillaceous limestone. G 75-6 MB. Tentaculitids: *Gotlandellites visbyensis*.

OIDEHOBURGA 1, *Slite Beds*, Slite Marl. Greenish-grey marl. MS 177, 245. Tentaculitids: *Turmalites slitiensis*.

OIVIDE 1, *Slite Beds*, *Conchidium tenuistriatum* Beds. Intercalations of brownish-grey marl in fine grained, slightly argillaceous limestone. MS 125. Tentaculitids: None.

OIVIDEKORSET 1, 637839 164413 (CJ 3291 7755), ca. 2025 m N of Eskelhem church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 160 Klintehamn.
Ditch exposure immediately NE of the crossroads at Övide, ca. 10 m W of point 26.65.
Slite Beds, Slite Marl. Brownish-grey marlstone and argillaceous limestone. G 73-58 KL. Tentaculitids: None.

OLSVENNE 4, 633071 164686 (CJ 3200 2982), ca. 4000 m SSW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.
Ditch exposure immediately SE of the road, ca. 1250 m NE of the crossroads at Skåls. Olsvenne 4 is situated 175 m S of the house.
Eke Beds, lowermost part. Greenish-grey, silty marl, rich in algae. G 72-97 KL. Tentaculitids: *Alternatus*? sp.

ÖSTERGARNBORRNINGEN 1, 637018 168541 (CJ 7343 6622), ca. 2000 m ESE of Östergarn church. Topographical map sheet 6J Roma SO. Geological map sheet Aa 170 Katthammarsvik.
Temporary excavation 50 m S of the road, ca. 360 m E of the house at Bengts. The excavation was made for the mudpit for the OPAB borehole Östergarn 1.
Hemse Beds, unit *c*. Bluish-grey marl and marlstone. G 73-5 KL. Tentaculitids: *Podolites hedei*?, *P. paeninsulicola*.

ÖSTERGARNSHOLM 1, *Hemse Beds*, unit *d*. Pockets of greenish-grey marl in dense crinoidal limestone. MS 840. Tentaculitids: None.

ÖSTERGARNSHOLM 2, *Hemse Beds*, unit *d*. Pockets of greenish-grey marl in dense crinoidal limestone. MS 832, 833. Tentaculitids: None.

ÖVERSTEKVARN 1, 640460 165487 (CK 4562 0285), ca. 4475 m SSW of Lummelunda church. Topographical map sheet 7J Fårösund SV & NV. Geological map sheet Aa 183 Visby & Lummelunda.
Ditch section immediately at the waterwheel at Lummelunda bruk (Överstekvarn).
Upper Visby Beds. Greenish-grey marl and marlstone. MS 870. Tentaculitids: *Alternatus*? sp., *Gotlandellites areolatus*, *Seretites*? *cataractae*, *S.*? *exilis*.

PETSARVE 1, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. MS 115, 300, 336, 348. Tentaculitids: *Odessites lauensis*?, *O. portensis*?, *O. prolatus*, *Tentaculites obstipus*.

PETSARVE 5, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. Got 76-17 SB. Tentaculitids: *Alternatus*? sp., *Odessites prolatus*.

PETSARVE 7, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. Got 76-16 SB. Tentaculitids: *Odessites portensis*, *O. prolatus*.

PETSARVE 8, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. Got 76-37 SB. Tentaculitids: *Odessites prolatus*.

PETSARVE 9, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. Got 76-14 SB, -15 SB. Tentaculitids: *Odessites prolatus*.

PETSARVE 12, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. Got 76-13 SB. Tentaculitids: *Odessites portensis*, *O. prolatus*?.

PETSARVE 15, *Eke Beds*, middle-upper part. Brownish-grey marl and argillaceous limestone rich in algae. Got 74-23, Got 76-12 SB. Tentaculitids: *Odessites portensis*?.

PUTTARSJAUS 1, *Slite Beds*, unit *g*. Pockets of greenish-grey marl in coarse grained, argillaceous limestone. MS 118, 120, G 75-1 KL. Tentaculitids: *Turmalites slitiensis*.

RAMMTRÄSK 1, *Hemse Beds*, lower-middle part. Pockets of greenish-grey, dense limestone rich in crinoids and stromatoporoids. MS 687, 723, 724. Tentaculitids: None.

RANGSARVE 1, *Hemse Beds*, upper part. Intercalations of bluish- and yellowish-grey marl in coarse grained, slightly argillaceous crinoidal limestone. MS 738, 739, 885, 886, 887, G 73-55 KL. Tentaculitids: *Dicricoconus* sp., *Odessites geretiensis*.

ROBBJÄNS 1, 636378 164352 (CJ 3121 6305), ca. 2440 m W of Klinte church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.
Excavation for culvert ditch at the SE end of new, paved road (not marked on topographical map sheet, ca. 500 m SE of the right-angled bend in the road.
Reference point: The SW end of the ditch.
Slite Beds, Slite Marl. Greenish- and brownish-grey marl. Got 76-47 SB, Got 77-16 SB. Tentaculitids: *Alternatus* sp., *Dicricoconus clintianus*, *D. svarvariensis*, *D. valliensis*.

ROBBJANS 2, 636415 164334 (CJ 3106 6344), ca. 2600 m WNW of Klinte church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.
Temporary excavation for drainage culvert immediately SE of new paved road (not marked on topographical map), ca. 20 m NE of right-angled bed in the road, and ca. 300 m SE of outermost house at Kalkugnskajan.
Slite Beds, Slite Marl. Brownish-grey marl. Got 76-46 SB. Tentaculitids: *Dicricoconus clintianus*.

ROBBJANS KVARN 1, *Slite beds*, Slite Siltstone. Light brownish-grey, calcareous siltstone and dense limestone. G 73-101 KL. Tentaculitids: None.

RONEHAMN 1, *Burgsvik Beds*, lowermost part. Grey, calcareous and micaceous siltstone. Unnumbered SGU sample. Tentaculitids: *Lonchidium ogmotum*, *Odessites portensis*.

RONEHAMN 2, 634144 166194 (CJ 4785 3937), ca. 4950 m SE of Rone church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV.
Large surface exposure 50 m south of the field road, ca. 575 m SW of the triangulation point at Ronehamn.
Reference point: The stone fence and field road intersection.
Eke Beds. Brownish-grey, silty marl and argillaceous limestone rich in algae: G 73-83 KL, -84 KL, -85 KL, G 75-29 KL. Tentaculitids: *Alternatus*? sp., *Lonchidium ogmotum*, *L. scanicum*, *Odessites portensis*, *O. prolatus*?.
Burgsvik Beds, lowermost part. Brownish-grey sandstone. G 73-86. Tentaculitids: None.
References: Hede 1925b, p. 27, bottom twenty lines, p. 28, lines 1-15 (contains list of fossils from the Eke Beds).

RONNINGS 1, *Eke Beds*, upper part. Grey silty marl. MS 221, 303, 314, 315, 715. Tentaculitids: *Lonchidium ogmotum*, *L. scanicum*?, *Odessites portensis*, *O. prolatus*.

ROVALDS 2, *Burgsvik Beds*, uppermost part. Yellowish-grey oolitic limestone and marl. G 74-33 KL, -34 KL. Tentaculitids: *Lonchidium scanicum*, *Tentaculites hisingeri*, *T. obstipus*?.

SANDARVE 1, *Hemse Beds*, upper part. Pockets of greenish- and brownish-grey marl in limestone rich in stromatoporoids and crinoids. MS 15, 66, 511. Tentaculitids: *Odessites geretiensis*.

SAXRIV 1, 642687 168289 (CK 7525 2290), ca. 6600 m NNE of Fleringe church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet 171 Kappelshamn.
Shore section along the northernmost point NW of Västerviken.
Högklint Beds, unit *b* (Hede's local units, *a*, *b*, and *c*). Grey, fine grained, argillaceous limestone rich in bryozoans. G 73-28, -29, -30, -31 (all KL). Tentaculitids: *Tentaculites liquis*.
References: Hede 1933, p. 23, bottom eleven lines, p. 24, lines 1-35 (contains list of fossils from measured section), p. 25, Fig. 10.

SIBBJANS 1, *Hamra Beds*, unit *b*. Light bluish-grey marlstone and argillaceous limestone. G 75-18 KL. Tentaculitids: *Odessites* sp.

SIGDES 1, 634320 166000 (CJ 4604 4126), ca. 2500 m SSE of Rone church. Topographical map sheet 5I Hoburgen. NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.
Ditch section running ca. 20 m NW of the small road between Alarve and south point 15.81, ca. 500 m SW of the five-way junction NE of Alarve. The locality comprises the distance 0.150 m SW of the reference point.
Reference point: The NE end of the ditch.
Eke Beds. Yellowish- and brownish-grey marl and marlstone. Got 76-21 SB, SMNH (unnumbered samples). Tentaculitids: *Odessites prolatus*, *Tentaculites hisingeri*, *T. obstipus*.

SIGFRIDE 1, *Slite Beds*, Slite Marl, northwesternmost part. Light greenish- and brownish-grey marl and argillaceous limestone. MS 854. Tentaculitids: *Dicricoconus acutalis*, *Seretites*? *versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

SIGSARVE 1, *Eke Beds*, lower part. Greenish-grey marl. MS 736. Tentaculitids: None.

SIGSARVESTRAND 1, 641962 166695 (CK 5882 1687), ca. 5350 m NW of Hangvar church. Topographical map sheet 7J Fårösund SV & NV. Geologisk map sheet Aa 171 Kappelshamn.
Cliff section ca. 1500 m N of the northernmost cottage at Sigsarvestrand.
Upper Visby Beds. Greenish-grey marl. MS 906. Tentaculitids: *Alternatus*? sp., *Gotlandellites areolatus*, *Seretites*? *cataractae*.
References: Hede 1933, p. 14, penultimate line.

SIGVALDE 1, *Hemse Beds*, lower part. Pockets of greenish- and brownish-grey marl in limestone rich in crinoids and stromatoporoids. MS 134, 274, 464, 602. Tentaculitids: *Alternatus*? sp., *Dicricoconus tenuissimus*?, *Odessites geretiensis*.

SINNARVE 1, *Slite Beds*, Slite Marl, *Conchidium tenuistriatum* Beds. Intercalations of brownish-grey marl in dense, argillaceous limestone. MS 117, 718. Tentaculitids: *Dicricoconus clintianus*?, *Dicricoconus* sp.

SJÄLSÖ 1, 639958 165206 (CJ 4244 9807), ca. 4050 m W of Västkinde church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.
Shore exposure ca. 250 m NNE of the ditch and road intersection at Själsö, ca. 150 m NE of the pill-box. The exposure is among the numerous erratic boulders scattered on the shore.
Lower Visby Beds. Greenish-grey marl and marlstone. G 72-42 KL, G 74-5 KL, -6 KL. Tentaculitids: *Gotlandellites visbyensis*, *Seretites*? *exilis*.

SJÄLSÖ 2, 639974 165225 (CJ 4265 9820), ca. 3090 m WNW of Västkinde church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.
Low cliff section above beach, on S side of mouth of small stream SW of Kronviken, 600 m NE of the northeasternmost house at Själsö Fiskehamn.

Lower Visby Beds. Grey marl and marlstone. G 75-5 MB, SMNH (unnumbered samples). Tentaculitids: *Gotlandellites visbyensis*.

References: Hede 1940, p. 10, line 18 from the bottom (reference to the area in general).

SKALASANDSVIK 1, 643083 170795 (DK 0052 2492), ca. 1500 m E of the triangulation point 22.3 at Lansa nässkifte. Topographical map sheet 7K Ullahau NV. Geological map sheet Aa 180 Fårö.

Shore section at the small point on the SW shore at Skalasandsvik, ca. 900 m ENE of the field crossroads G 73-8 KL. Tentaculitids: None.

References: Hede 1936, p. 33, bottom twenty-four lines, p. 34, lines 1-6 (contains list of fossils from measured section).

SKÅNE 1, *Hemse Beds*, unit *c*. Intercalations of brownish-grey marl in fine grained limestone. MS 179, 3-2. Tentaculitids: None.

SKÄRET 1, 632518 165382 (CJ 3852 2378), ca. 2525 m ESE of Öja church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Low shore exposure on the southern side of the small point SW of Skäret.

Hamra Beds. Yellowish-brown marl. G 73-79 KL. Tentaculitids: *Lonchidium extensum*, *L. groetlingboense*, *L. umidestre*.

SLÄTHÄLLAR 2, 643103 169373 (CK 8637 2621), ca. 6000 m NW of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Cliff section, ca. 50 m along the shore, ca. 1120 m N of the triangulation point at Lauterhorn.

Reference point: Vertical yellow marking at roughly the middle of the exposure.

Reference level: Base of coarse, bryozoan-crinoidal, detrital limestone (marked by a horizontal yellow line) overlying a 60 cm sequence of alternating marl and brownish, dense calcilutite.

Högklint Beds, middle part. Brownish-grey marlstone and argillaceous limestone. G 74-73 KL, G 75-11 KL, -12 KL. Tentaculitids: *Tentaculites liquis*, *Turmalites follingboensis*.

References: Hede 1936, pp. 13-14 (reference to the area in general).

SLÄTHÄLLAR 3, 643051 169362 (CK 8622 2570), ca. 5650 m NW of Fårö church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Shore exposure from ca. 100 m S of the southern shore of the small point named Släthällar (and ca. 700 m NNW of the triangulation point at Lauterhorn) southwards along the shore until covering beach gravel ends the continuous exposure. The exposure has a group of bioherms in its central part.

Högklint Beds, middle part. Brownish-grey argillaceous limestone. Got 75-42 KL. Tentaculitids: *Tentaculites limatulus*, *T. liquis*.

References: Hede 1936, pp. 13-14 (reference to the area in general).

SLITEBROTTET 1, *Slite Beds*, Slite Marl. Greenish-grey marl and marlstone. MS 30, 32, 482. G 73-2 CB. Tentaculitids: *Turmalites slitiensis*.

SMISS 1, *Klinteberg Beds*, Klinteberg Marl. Brownish-grey marl and calcareous marlstone. Got 74-40 SB. Tentaculitids: *Dicricoconus aemulus*.

SMISSHAGMYR 1, 638695 166877 (CJ 5818 8420), ca. 2640 m NE of Hörsne church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Ditch section from the road (not marked on the topographical map sheet) to Lina Myr which lies ca. 100 m SE of the road going NE from Norrbys, at the northern corner of the small wood. The section continues ca. 120 m SW and then ca. 20 m SE.

Reference point: The right-angled bend in the ditch.

Halla Beds, middle part. Grey, dense, slightly argillaceous, reef limestone. Tentaculitids: None.

References: Hede 1928, p. 48, bottom four lines, and p. 49, lines 1-3 (contains list of fossils).

SMOJGE 1, *Halla Beds*, lower part. Marly intercalations in greenish-grey, dense, silty limestone. MS 830, 831, 855, 858. Tentaculitids: None.

SNÄCKGÄRDSBADEN 1, *Upper Visby Beds*, upper part. Brownish-grey marl and argillaceous limestone. MS 428, 429, 430, G 72-2 KL, -3 KL, G 74-56 KL. Tentaculitids: *Alternatus*? sp., *Gotlandellites areolatus*, *Seretites*? *exilis*.

SNAUVALDS 1, *Hemse Beds*, Hemse Marl, northwestern part. Bluish-grey calcareous shale. MS 670, G 72-99 KL. Tentaculitids: None.

SNEVIDE 1, 634006 165363 (CJ 3946 3862), ca. 1300 m ESE of Havdhem church. Topographical map sheet 5I Hoburgen. NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.

Debris filling in trench for a cable 75 m NNE of the crossroads west of the windmill at Snevide. The small road runs to a dump.

Reference point: The junction between the small road and the trench. Snevide 1 comprises the distance 0-150 m ENE of the junction.

Eke Beds, lower part. Brownish- and bluish-grey marl and argillaceous limestone rich in algae. G 75-9 KL, Got 76-27 SB. Tentaculitids: *Odessites prolatus*.

SNIPPSNYTE 1, 634109 165113 (CJ 3705 3984), ca. 1500 m NW of Havdhem church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 164 Hemse.

Ditch section 100 m NE of the road and ditch intersection at Snippsnyte.

Hemse Beds, Hemse Marl. Bluish-grey marl and marlstone. MS 558. Tentaculitids: None.

References, Martinsson 1967, p. 370, lines 10-11 from the bottom.

SNODER 1, *Hemse Beds*, Hemse Marl, northwestern part. Bluish-grey marl, calcareous shale and argillaceous limestone. MS 156, 431, 768, G 73-72 KL, -73 KL. Tentaculitids: *Dicricoconus aemulus*.

SNODER 2, *Hemse Beds*, Hemse Marl, northwestern part. Bluish-grey marl and argillaceous limestone. MS 627, 869, 874, G 72-31 KL. Tentaculitids: *Dicricoconus aemulus*, *Odessites* sp.

SOJVIDE 1, 637798 164528 (CJ 3403 7705), ca. 1925 m SW of Eskelhem church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 160 Klintehamn.

Ditch section 25 m SW of the ditch and road intersection, ca. 825 m W of the crossroads at Sojvide.

Slite Beds, *Conchidium tenuistriatum* beds. Grey marl and marlstone. MS 798, G 73-59 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *Turmalites follingboensis*?.

References: Hede 1927, p. 28, line 22.

SOLKLINT 1, 640208 167819 (CJ 6867 9856), ca. 125 m NNW of Slite church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 169 Slite.

Inland cliff section on the eastern side of the hill Solklint, ca. 15 m E of the main road and ca. 100 m S of the main crossroads NNW of the church.

Reference point: The northwesternmost reef exposure at Solklint.

Slite Beds: unit *g*. Pockets of marl in greenish-grey, dense limestone. MS 551, 569, 628, 880, G 73-63 KL. Tentaculitids: *Alternatus*? spp., *Dicricoconus clintianus*, *D. gutnicus*, *Turmalites slitiensis*.

References: Hede 1928, p. 14, line 12, p. 26, lines 6-16.

SPILLINGS 1, *Slite Beds*, unit *g*. Intercalations of grey marl in crinoidal limestone. MS 349, 628, 759. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*?, *Turmalites slitiensis*.

STAJNKROGEN 1, 639868 165239 (CJ 4270 9714), ca. 3750 m W of Väskinde church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 183 Visby & Lummelunda.

Road section immediately SE of the road, ca. 450 m SW of point 35.88.

Högklint Beds. Pockets of brownish-grey marl in dense limestone. MS 774. Tentaculitids: None.

References: Hede 1940, p. 25, lines 27-28.

STAVE 1, *Slite Beds*, Slite Marl. Bluish-grey marl and argillaceous limestone. MS 74, G 73-40 KL. Tentaculitids: *Dicricoconus acutalis*?, *D. clintianus*?, *D. gutnicus*, *Seretites*? *versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

STENSTU 1, 637537 167431 (CJ 6276 7224), ca. 1150 m SSE of Anga church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 170 Katthammarsvik.

Ditch section immediately W of the road and ditch intersection at point 12.8, ca. 375 m SSW of the easternmost house at Stenstugu.

Klinteberg Beds, upper part. Pockets of brownish-grey marl in dense limestone. MS 636. Tentaculitids: None.

STENSTUGÅRDS 2, 637467 165709 (CJ 4555 7285), ca. 2000 m WNW of Viklau church. Topographical map sheet 6J Roma SV. Geological map sheet Aa 160 Klintehamn.

Ditch section ca. 170 m N of the road and ditch intersection.

Halla Beds, middle part. Bluish- to brownish-grey, fine grained limestone. Tentaculitids: None.

References: Hede 1927a, p. 34, lines 33-35.

STORA BANE 1, *Slite Beds*, unit *g*. Intercalations of brownish-grey marl in fine grained limestone rich in stromatoporoids. MS 186, 481. Tentaculitids: None.

STORA DÄPPAN 1, 633625 164697 (CJ 3253 3533), ca. 2775 m NW of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Ditch exposure immediately SW of the crossroads NE of St. Däppan.

Hemse Beds, Hemse Marl, northwestern part. Grey marlstone and dense argillaceous limestone. G 73-99 KL. Tentaculitids: None.

STORA HAJSLUNDS 1, *Eke Beds*, lowermost part. Pockets of greenish-grey marl in fine grained, argillaceous limestone. MS 666. Tentaculitids: *Odessites prolatus*.

STORA MYRE 1, *Slite Beds*, unit *d*. Brownish-grey marl and fine grained, argillaceous limestone. MS 34, 127, 145, 162, 407, 575, G 72-15 KL. Tentaculitids: *Turmalites follingboensis*?, *T. slitiensis*?.

STORA VEDE 1, *Slite Beds*, unit *g*. Intercalations of brownish marl in fine grained, dense limestone. MS 549, G 74-55 KL. Tentaculitids: *Alternatus*? sp., *Turmalites follingboensis*.

STORBURG 1, *Hamra Beds*. Intercalations and pockets of brownish-grey marl in reef limestone and dense crinoidal limestone. MS 7, 41, 43, 90, 204, 247, 250, 256, 264, 316, 426, 427, 439, 459. Tentaculitids: *Odessites majstriensis*, *Odessites* sp.

STORBURG 2, *Sundre Beds*, upper part. Pockets of greenish-grey marl in dense crinoidal limestone. MS 106, 166, 200, 325, 337. Tentaculitids: None.

STORMYR 1, *Slite Beds*, Slite Marl, northwestern part. Grey marl and dense argillaceous limestone. MS 857. Tentaculitids: None.

STRANDS 1, *Hamra beds*, unit *b*. Brownish-grey marl. MS 600. Tentaculitids: None.

STRANDS 2, 632413 164925 (CJ 3392 2311), ca. 5900 m NNE of Vamlingbo church. Topographical map sheet 5I Hoburgen SO & 5J SV. Geological map sheet Aa 152 Burgsvik.

Ditch exposure 10 m E of the road, ca. 50 m W of point 4.70 NE of Strands.

Hamra Beds, unit *b*. Brownish-grey marl. G 75-17 KL. Tentaculitids: *Lonchidium groetlingboense*?, *Lonchidium umidestre*.

STRÅ KALKBRUK 1, 642163 168916 (CK 8110 1720), ca. 3300 m NW of Bunge church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Abandoned quarry immediately SW of the crossroads at Stucks.

Reference point: The northwestern corner of the quarry.

Slite Beds. Intercalations of light grey marl in dense, fine grained limestone. G 73-32 KL. Tentaculitids: None.

SUDERBYS 1, 638740 167434 (CJ 6371 8422), ca. 950 m WNW of Gothem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Ditch exposure immediately NE of the road, ca. 150 m ENE of the northwesternmost house at Suderbys.

Klinteberg Beds, unit *b*. Pockets of brownish-grey marl in dense limestone. MS 637. Tentaculitids: None.

SUDERBYS 2, 638734 167454 (CJ 6390 8415), ca. 725 m WNW of Gothem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Ditch section immediately NE of the road, ca. 325 m E of the northwesternmost house at Suderbys. The locality is S of the SE corner of the small forest.

Klinteberg Beds, unit *b*. Pockets of brownish-grey marl in dense limestone. MS 638, 904. Tentaculitids: *Tentaculites gothemensis*?.

SUDERSANDSVIKEN 1, 642966 170260 (CK 9510 2417), ca. 525 m NE of the triangulation point 20.4 at Gasmorhammaren. Topographical map sheet 7K Ullahau NV. Geological map sheet Aa 180 Fårö.

Shore exposure on the SW shore of Sudersandsviken, ca. 275 m NE of the house north of *r* in Gasmora.

Slite Beds, Slite Marl. Brownish-grey marlstone and fine grained, argillaceous limestone. G 73-9 KL. Tentaculitids: *Dicricoconus gutnicus*, *Tractabilopsis serratus*.

SUDERSLÄTT 1, *Klinteberg Beds*, lower part. Intercalations of greenish-grey marl in fine grained, argillaceous limestone. MS 828. Tentaculitids: None.

SUNNKYRKE 1, *Eke Beds*, lower part. Greenish- and brownish-grey marl. Got 76-18 SB. Tentaculitids: *Alternatus*? sp.

SVANÄSUDD 1, 639740 167894 (CJ 6906 9384), ca. 3375 m SE of Boge church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Shore exposure at the point SE of Gylviken, ca. 200 m NNE of the house SE of Sudervik.

Slite Beds, Slite Marl. Brownish-grey argillaceous limestone. G 73-43 KL. Tentaculitids: None.

SVARVARE 1, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Grey marl, marlstone and argillaceous limestone. MS 4, 54, 56, 68, 123, 137, 143, 159, 270, 346, G 72-19 KL, G 74-68 KL, Got 75-6 SB, -7 SB, G 75-3 B MB. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *D. svarvariensis*.

SVARVARE 2, 636336 164416 (CJ 3178 6255), ca. 1960 m WSW of Klinte church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

Ditch exposure and material dug out from ditch 60 m E of the intersection of the ditch and main road, NNW of Svarvare (60 m E of Svarvare 1).

Slite Beds, Slite Marl, uppermost part. Grey marl and marlstone. G 75-3A MB. Tentaculitids: *Dicricoconus clintianus*.

SVARVARE 3, 636336 164494 (CJ 3170 6256), ca. 2020 m WSW of Klinte church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

Ditch exposure immediately E of main road, at the mouth of the culvert where the ditch from the W side of the road meets the N-S ditch (30 m N of Svarvare 1).

Slite Beds, Slite Marl. Grey marl and marlstone. G 75-3C MB. Tentaculitids: *Dicricoconus svarvariensis*, *D. valliensis*.

SVARVEN 1, *Högklint Beds*. Brownish-grey marl and argillaceous limestone. MS 667, 668, 707, 708, 709, 879, G 73-66 KL. Tentaculitids: *Alternatus*? sp., *Seretites*? *cataractae*, *Tentaculites limatulus*, *T. liquis*.

SYSNE 1, 636698 168506 (CJ 7283 6306), ca. 5000 m ESE of Gammelgarn church. Topographical map sheet 6J Roma SO. Geological map sheet Aa 170 Katthammarsvik.

Section immediately E of the road, ca. 280 m SSW of the westernmost crossroads at Sysne.

Hemse Beds, unit *d*. Brownish-grey marl and argillaceous limestone. G 73-7 KL, G 74-28 KL. Tentaculitids: *Alternatus*? spp, *Odessites inflatus*.

References: Hede 1929, p. 42, bottom twelve lines, p. 44, lines 1-2 (contains list fo fossils).

SYSNEUDD 1, 636605 168515 (CJ 7285 6212), ca. 4650 m SSE of Östergarn church. Topographical map sheet 6J Roma SO. Geological map sheet Aa 170 Katthammarsvik.

Shore exposure at the extreme point of Sysneudd.

Hemse Beds, unit *d*. Grey, coarse grained, crinoidal limestone. Tentaculitids: *Alternatus*? sp., *Odessites inflatus*.

References: Hede 1929, p. 42, lines 3-6 (contains list of fossils).

TALINGS 1, *Slite Beds*, unit *g*. Intercalations of brownish-grey marl in fine grained argillaceous limestone. MS 761. Tentaculitids: None.

TÄNGLINGS 1, *Hemse Beds*, lower-middle part. Intercalations of brownish-grey marl in limestone rich in stromatoporoids. MS 107, 329, 394, 465. Tentaculitids: *Alternatus*? sp., *Dicricoconus aemulus*?, *D. tenuissimus*?, *Odessites geretiensis*.

TÄNGLINGS 2, *Hemse Beds*, lower-middle part. Intercalations of brownish-grey marl in slightly argillaceous limestone. MS 656, G 72-63 KL. Tentaculitids: None.

TASS 1, 636786 165340 (CJ 4135 6635), ca. 800 m ESE of Hejde church. Topographical map sheet 6J Roma SV.

Abandoned quarry ca. 475 m ESE of the main crossroads E of Hejde. The quarry is marked on the topographical map sheet.

Klinteberg Beds, lower part. Intercalations of greenish-grey marl in dense crinoidal limestone. G 73-56 KL. Tentaculitids: None.

TINGS 1, *Klinteberg Beds*, unit *f*. Pockets of brownish-grey marl in fine grained limestone rich in stromatoporoids. MS 618, 619. Tentaculitids: None.

TJÄNGDARVE 1, *Hemse Beds*, Hemse Marl, southeastern part. Brownish- and yellowish-grey marl and marlstone. MS 259, 261, G 75-10 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus tenuissimus*, *Odessites inflatus*.

TJAUTET 1, *Slite Beds*, unit *e*. Intercalations of brownish-grey marl in dense limestone. G 72-40 KL. Tentaculitids: None.

TJELDERSHOLM 1, *Slite Beds*, *Pentamerus gotlandicus* Beds - *Atrypa reticularis* Beds. Intercalations of brownish-grey marl in dense, argillaceous limestone. MS 743, 744, 856, G 73-45 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus acutalis*, *D.* aff. *gutnicus*, *D. valliensis*.

TJULS 1, *Slite Beds*, Slite Marl, middle part. Grey marl and dense, argillaceous limestone. MS 752. Tentaculitids: *Alternatus*? spp., *Dicricoconus clintianus*, *D. valliensis*?, *Turmalites follingboensis*?.

TJULS 2, 0000 0000, ca. 3275 m NNE of Sanda church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

Dumped rock from a well digging at 637282 164605 (CJ 3440 7185) immediately NW of the road and ditch intersection at Tjuls. The dump is situated at 637277 164608 (CJ 3444 7188).

Slite Beds. Grey marl and argillaceous limestone. MS 897. Tentaculitids: *Alternatus*? sp., *Turmalites follingboensis*.

TJULS 3, 637284 164610 (CJ 3445 7187), ca. 3260 m NNE of Sanda church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

Ditch exposure immediately NE of the road and ditch intersection at Tjuls.

Slite Beds. Greenish-grey marl and argillaceous limestone. MS 898. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *Seretites*? *versabilis*, *Turmalites follingboensis*.

TOJVIK 1, 641858 169627 (CK 8795 1361), ca. 5250 m ESE of Bunge church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 180 Fårö.

Shore exposure on the SW shore of the peninsula of Ryssnäs, ca. 825 m NW of the triangulation point at Ryssnäs.

Slite Beds, Slite Marl. Greenish- and brownish-grey, silty marl and marlstone. G 73-17 KL. Tentaculitids: None.

TOMASE 1, 639905 166333 (CJ 5363 9667), ca. 325 m ESE of Lokrume church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Ditch section immediately N of the ditch and road intersection, ca. 575 m WNW of the northwesternmost house at Tomase.

Slite Beds. Greenish-grey marl. MS 725. Tentaculitids: None.

References: Hede 1928, p. 18, lines 11-25 (contains list of fossils).

TOMSARVE 1, *Eke Beds*, lower part. Bluish-grey marlstone and marl. G 75-21 KL. Tentaculitids: *Dicricoconus* sp., Gen. et sp. indet.

TORSBURGEN 1, 636942 167511 (CJ 6310 6623), ca. 5250 m WNW of Gammelgarn church. Topographical map sheet 6J Roma SO. Geological map sheet Aa 170 Katthammarsvik.

Cliff section at the NE entrance (Tjängvide lucka) to the ancient stronghold of Torsburgen, ca. 75 m NE of the tower.

Hemse Beds. Brownish-grey marl intercalated in dense limestone. MS 692, 790, G 73-102 KL. Tentaculitids: *Odessites inflatus*.

References: Hede 1929, p. 50, lines 6-16.

TRÄDGÅRDEN 1, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Intercalations of brownish- and greenish-grey marl in fine grained, slightly silty and argillaceous limestone. MS 829. Tentaculitids: None.

TRÄSKE 1, *Hemse Beds*, unit *b*. Brownish-grey marlstone and argillaceous limestone. G 74-30 KL. Tentaculitids: *Podolites ternatus*.

TROSINGSGÄRDET 1, *Hemse Beds*, unit *a*. Intercalations of brownish-grey marl in coarse grained limestone rich in crinoids. MS 693. Tentaculitids: None.

TROSINGSGÄRDET 2, *Hemse Beds*, unit *a*. Grey to brownish-grey, coarse grained limestone. G 73-4 KL. Tentaculitids: None.

TUBOD 2, 633025 165378 (CJ 3887 2884), ca. 1500 m E of Fide church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Surface exposure 50 m S of the field road, ca. 325 m ESE of the crossroads north of the shooting range. The locality is largely covered with beach sand.

Hamra Beds. Yellowish-brown marl and marlstone. G 73-81 KL. Tentaculitids: *Alternatus*? sp.

UDDVIDE 1, *Burgsvik Beds*, uppermost part. Light grey, micaceous, calcareous, fine grained sandstone; grey, argillaceous, oolitic limestone; brownish-grey micaceous, silty, calcareous clay and shale. G 72-33 KL, -34 KL, -35 KL, -36 KL, G 73-78 KL. Tentaculitids: *Alternatus*? sp., *Lonchidium scanicum*, *Odessites portensis*, *Tentaculites hisingeri*.

Hamra Beds, unit *a*. Brownish-grey, argillaceous, algal limestone. MS 80, 86, 130, 239, 309, 393, 423, 552, 659. Tentaculitids: *Alternatus*? spp.

VAKTÅRD 1, 633355 164584 (CJ 3120 3273), ca. 3075 m W of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Shore exposure immediately NW of the fishing-house at Vakten.

Hemse Beds, Hemse Marl. Bluish-grey, dense, calcareous shale and marlstone. G 72-91 KL, G 73-97 KL. Tentaculitids: *Dicricoconus tenuissimus*.

References: Hede 1919a, locality 7, p. 19, lines 11-36, p. 20, lines 1-23 (contains list of fossils); Hede 1942, p. 20, locality 3c, Fig. 2.

VAKTÅRD 2, 633359 164611 (CJ 3147 3275), ca. 2800 m W of Näs church. Topographical map sheet 5I Hoburgen NO & 5J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Low ditch exposure immediately E of the road, ca. 50 m NE of the small bight E of the fishing-house at Vakten. The locality is at the sharp bend of the road, at the cattle-grid.

Hemse Beds, Hemse Marl. Bluish-grey dense marlstone with intercalations of fine grained limestone. G 73-98 KL. Tentaculitids: *Dicricoconus tenuissimus*.

VAKTEN 1, *Hemse Beds*, Hemse Marl, northwestern part. Bluish-grey marl and marlstone. G 72-88 KL. Tentaculitids: *Dicricoconus* sp.

VALAR 2, *Burgsvik Beds*, upper part. Brownish-grey marl. Yellowish-brown, silty, pisolitic limestone. G 73-91 KL, -92 KL. Tentaculitids: *Tentaculites obstipus*.

VALBYTTE 1, *Slite Beds*, Slite Marl. Greenish-grey marl and marlstone and dense argillaceous limestone. MS 441, 442, G 74-38 KL, Got 76-45 SB. Tentaculitids: *Alternatus*? sp., *Dicricoconus gutnicus*, *Seretites*? *versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

VALBYTTE 2, 636852 164091 (CJ 2395 6796), ca. 2275 m S of Västergarn church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

Surface exposure immediately E of the road, ca. 550 m NNW of the millstone NW of Koviken. The locality is immediately N of a small field road (not marked on the topographical map) at the northern edge of the field.

Slite Beds, Slite Marl. Bluish-grey marlstone and argillaceous limestone. G 74-19 KL, G 75-30 KL. Tentaculitids: *Alternatus*? sp., *Tentaculites* spp., *Turmalites follingboensis*.

VALLE 1, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Brownish-grey marl and argillaceous limestone. MS 684, 690, G 74-39 KL, Got 75-4 SB, Got 76-24 SB, -25 SB. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *D. svarvariensis*, *D. valliensis*.

VALLE 2, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Greenish-grey marl. MS 691. Tentaculitids: *Dicricoconus clintianus*, *D. svarvariensis*.

VALLE 3, 636529 164550 (CJ 3330 6439), ca. 1350 m NNW of Klinte church. Topographical map sheet 6I Visby SO. Geological map sheet Aa 160 Klintehamn.

Ditch exposure SE of the road; one ditch running parallel to the road crosses a second at ca. 45° angle to it ca. 220 m WSW of the crossroads at Valle 1.

Reference point: The junction of the ditches.

Slite Beds, Slite Marl. Brownish-grey marl. Got 76-26 SB. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *D. svarvariensis*, *D. valliensis*.

VALLEVIKEN 1, *Slite Beds*, Slite Marl. Light brownish- and greenish-grey marlstone and argillaceous limestone. MS 834, 835, 836, G 73-36 KL. Tentaculitids: *Alternatus*? sp., *Dicricoconus clintianus*, *D. gutnicus*, *Seretites*? *versabilis*, *Turmalites follingboensis*, *T. slitiensis*.

VALLMYR 1, 638538 167664 (CJ 6585 8293), ca. 2250 m SE of Gothem church. Topographical map sheet 6J Roma NV & NO. Geological map sheet Aa 169 Slite.

Section in the ditch between Vallmyr and Storsund, ca. 50 m NE of the ditch and road intersection (=point 7.3). The locality is on the southern side of the ditch, and comprises 50-100 m E of the bridge.

Reference point: The eastern side of the road bridge over the ditch.

Klinteberg Beds, unit *d*. Bluish-grey marlstone and argillaceous limestone. MS 633, 902, G 72-101 KL. Tentaculitids: *Podolites hedei*, *P. ternatus*, *Tentaculites gothemensis*.

References: Hede 1928, p. 50, bottom four lines, p. 60, lines 1-9.

VALLSTENA 1, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Greenish-grey marl, marlstone and argillaceous limestone. MS 22, 65, 75, 326, 332, 471, 5-9, Got 74-27 SB. Tentaculitids: *Alternatus*? sp., *Turmalites slitiensis*, *Turmalites*? sp.

VALLSTENA 2, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Greenish-grey marl and argillaceous limestone. G 72-18 KL, G 74-61 KL. Tentaculitids: *Alternatus*? sp.

VANGES 1, *Hemse Beds*, Hemse Marl, southeastern part. Grey silty marl and argillaceous, silty limestone. MS 226. Tentaculitids: None.

VÄSTARBERGET 1, *Slite Beds*, Slite Marl, Lerberget marl. Brownish-grey, silty marl and argillaceous, slightly silty limestone. MS 411, 412, 413, 414, 415. Tentaculitids: None.

VÄSTLAUS 1, *Hemse Beds*, Hemse Marl, southeastern part. Brownish- and greenish-grey marl. MS 216, 222, SMNH (unnumbered sample). Tentaculitids: *Odessites inflatus*.

VÄSTÖS 1, *Högklint Beds*, unit *b*. Intercalations of grey marl in fine grained limestone rich in stromatoporoids. MS 39, 564, 677. Tentaculitids: *Tentaculites limatulus*, *T. liquis*.

VÄSTÖS 2, 642191 167610 (CK 6810 1848), ca. 6400 m WNW of Fleringe church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Shore section ca. 50 m S of the outlet of "Kristikanal".

Högklint Beds, unit *b*. Dense grey marlstone and argillaceous limestone. G 72-45 KL. Tentaculitids: *Seretites*? *cataractae*, *Tentaculites liquis*.

VÄSTÖS 3, 642241 167581 (CK 6785 1900), ca. 6800 m WNW of Fleringe church. Topographical map sheet 7J Fårösund SO & NO. Geological map sheet Aa 171 Kappelshamn.

Temporary well digging E of the small field road, ca. 575 m SE of the crossroads at Västös.

Upper Visby and Högklint Beds, unit *a*.of the latter. Högklint Beds: Brownish-grey marl. MS 728, 729, 730. Tentaculitids: *Alternatus*? spp., *Gotlandellites aerolatus*, *Seretites*? *cataractae*.

VATTENFALLSPROFILEN 1, *Upper Visby Beds*. Mainly, alternating beds of grey marlstone and limestone. Tentaculitids: *Alternatus*? spp. (3.9-10.0 m), *Gotlandellites areolatus* (1.7-10.0), *Seretites*? *exilis* (1.0-1.9 m), *S.*? *cataractae* (8.4- 10.0 m), *S.*? cf. *cataractae* (7.0 m), *Tentaculites* cf. *limatulus* (9.0 m).

Högklint Beds. Interbedded grey limestone and marlstone, grey dense limestone, and dark grey, bituminous mudstone. Tentaculitids: *Alternatus*? spp., (10.7-21.2 m), *Gotlandellites areolatus* (10.7-19.8 m), *Seretites*? *cataractae* (10.7-21.2 m), *S.*? *cataractae*? 21.9-22.9 m), *Tentaculites limatulus* (25.1-26.7 m), *T.* cf. *limatulus* (27.3-29.8 m).

VIBBLE 1, 638922 164568 (CJ 3528 8823), ca. 2650 m N of Västerhejde church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.

Temporary excavation for foundations of a new house (not marked on the topographical map sheet). There is a new road (not marked on the topographical map sheet) running from the sharp, easternmost bend of the main road at Kneippbyn to the southwesternmost corner of the village of Vibble. Vibble 1 is located ca. 25 m W of that road.

Tofta Beds. Greenish-grey marlstone and dense limestone. G 73-95 KL. Tentaculitids: None.

VIDFÄLLE 1, *Hemse Beds*, unit *b*. Greenish-grey marl and dense, argillaceous limestone. MS 555, 630, 893. Tentaculitids: *Alternatus*? sp., *Podolites hedei*, *P. ternatus*.

VIKE 1, *Slite Beds*, Slite Marl, *Pentamerus gotlandicus* Beds. Brownish-grey marl and marlstone. MS 701, G 73-44 KL. Tentaculitids: None.

VISBYBORRNINGEN 1, 639211 164765 (CJ 3747 9097), ca. 1825 m SW of Visby cathedral. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.

Borehole drilled in the old marl-pit (Lergraven) of the former Visby Cementfabrik. The borehole was drilled 1911-1912 and reached a total depth of 403.14 m. The well head was situated 4.6 m below sea level. The borehole is now covered with dump.

Lower Visby Beds? 60.90-61.54 m, 104.90-106 m. Tentaculitids: *Gotlandellites visbyensis*?.

References: Hedström 1923a; Hedström 1923b; Thorslund & Westergård 1938, p. 40-41; Hede 1940, p. 10, bottom nine lines; Martinsson 1967, p. 357, lines 15-25; Manten 1971, pp. 14, 29, 32, and 48.

VIVUNGS 1, *Klinteberg Beds*, middle-upper part. Intercalations of greyish-brown marl in coarse grained limestone rich in crinoids and stromatoporoids. MS 639. Tentaculitids: None.

YGNE 1, *Upper Visby Beds*, uppermost part. Greenish-grey marl and argillaceous limestone. MS 14, 69, 482. Tentaculitids: *Alternatus*? sp., *Gotlandellites areolatus*, *Seretites*? *cataractae*.

YGNE 2, *Upper Visby Beds*, uppermost part. Brownish- and greenish-grey marl and calcareous mudstone. G 74-1 KL, -2 KL, Got 76-1 SB. Tentaculitids: *Gotlandellites areolatus*, *Seretites*? *cataractae*, *S.*? *exilis*.

YGNE 3, 638794 164270 (CJ 3223 8720), ca. 3675 m WNW of Västerhejde church. Topographical map sheet 6I Visby NO. Geological map sheet Aa 183 Visby & Lummelunda.

Cliff section at Rövar Liljas Håla, ca. 150 m NE of the end of the road (on the topographical map sheet, where the northwesternmost road becomes only a path).

Reference level: The boundary between Upper Visby and Högklint Beds.

Upper Visby Beds, uppermost part. Brownish- and greenish-grey marl and argillaceous limestone. G 74-3 KL, Got 76-4 SB, -5 SB, -6 SB. Tentaculitids: *Alternatus*? sp., *Gotlandellites areolatus*, *Seretites*? *cataractae*, *S.*? *exilis*.

Högklint Beds, unit *a*. Intercalations of brownish-grey marl in dense limestone. Tentaculitids: None.

References: Holm 1890, p. 14; Munthe 1921b, Figs. 74, 75, p. 37, lines 14-35; Hede 1940, p. 17, line 7 from the bottom (reference to the area in general); Hede 1942, p. 4, locality 5; Ericsson & Laufeld 1977.

YXNE 1, *Slite Beds*, unit *d*. Brownish-grey marl. MS 68. Tentaculitids: None.

The following three localities are not described formally as the original locality descriptions of the museum samples are too poor.

"GRÖTLINGBOUDD", about 5000 m ESE of Grötlingbo church. Topographical map sheet 5 I Hoburgen NO & 5 J Hemse NV. Geological map sheet Aa 152 Burgsvik.

Remarks: SMNH samples from this locality were collected by Holm in 1899 and labelled "southern side of Grötlingboudd". From lithological reasons it is clear that the samples derive from unit *b* of the Hamra Beds, and consequently they must come either from the shore of Austerviken, 633475 165875 to 633475 165920, or from the area around Bankvät 1.

"HUNSTÄDE", about 3700 m WSW of Fleringe church. Topographical map sheet 7 J Fårösund SO/NO. Geological map sheet Aa 171 Kappelshamn.

Remarks: SMNH samples from this locality are labelled "Hunstäde, Högklint Beds". From lithological reasons it is likely that they derive from exposures in the Högklint Beds, unit *b* along the shore of Hunstädeviken, i.e. immediately south of Horsan 1.

"PETESVIKEN", about 5500 m W of Hablingbo church. Topographical map sheet 5 I Hoburgen NO & 5 J Hemse NV. Geological map sheet Aa 164 Hemse.

Remarks: The sample from this locality is labelled by Hede as "Petesviken at the southern one of the two crosses on my economical map". As this map has not been possible to trace, it is unclear if his locality correspond to the classical Petesvik locality (=Lilla Hallvards 1 in Laufeld 1974a) or not. Due to faunal differences with the latter locality it is likely that Hede's "Petesviken" refers to a locality in beds slightly lower in the Hemse Beds than at Lilla Hallvards 1, i.e. somewhat north of that locality.

SCANIA

BJÄRSJÖLAGÅRD 1, 617961 136801 (VB 1870 7672), ca. 2300 m NW of Ö. Kärrstorp church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Section along drainage ditch from Sjömossen 0-200 m NW and 0-120 m SE of the bridge on the Djupadal to Bjärsjölagård road.

Reference point: The bridge.

Reference level: The mean water level in the canal.

Öved-Ramsåsa Beds, layers 1*a* and 1*b* *sensu* Grönwall (1897). Marly grey shale and marlstones, occasionally silty and micaceous, alternating with thin limestone beds (1*a*). Grey limestone, occasionally thickly bedded and biostromal, grey micaceous silty shale and marlstone (1*b*). Bj 67-30, -35, -37, -38, -41 (all LJ), Bj 74-1 KL, -2 KL, unnumbered PDL samples. Tentaculitids: *Lonchidium inclinense*, *Odessites inflatus*, *O. petilus*.

References: Tullberg 1882a, p. 24, bottom 14 lines (*partim*); 1882b, p. 13, bottom 11 lines - p. 14, lines 1-8 (contains list of fossils); Eichstädt 1888, p. 42, lines 23-27, p. 143, line 2 - p. 144, line 12 (contains list of fossils); Grönwall 1897, p. 21, line 20 from bottom - p. 22, line 22 (contains list of fossils); Mori 1969, p. 44, bottom 16 lines - p. 46, lines 1-3, Fig. 2; Jeppsson 1974, p. 50. The following papers give reference to the Bjärsjölagård area in general and thus to all localities in the Bjärsjölagård area: Bromell 1725-1729, p. 534; Wahlenberg 1818, p. 13; Hisinger 1828, p. 187; 1837a, p. 162, line 11; Murchison 1847; Angelin 1854, p. VIII; Erdmann 1872, p. 5; Angelin & Lindström 1880; Tullberg 1883, p. 232, line 9 from bottom; Törnebohm & Hennig 1904, p. 67; Hadding 1929, pp. 191-192.

Note: It is recommended that reference to the bridge be made for all future sampling of the canal section, cf. Jeppsson 1974, p. 50.

BJÄRSJÖLAGÅRD 2, 617940 136817 (VB 1887 7648), ca. 2050 m NW of Ö. Kärrstorp church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Abandoned quarry partly filled with water, 225 m SE of the Djupadal to Bjärsjölagård road from which there is a small road to the quarry (marked on the topographical map). The locality includes the drainage ditch SE from the quarry to the junction with the larger canal from Sjömossen. The quarry is marked as a pond on the topographical map.

Reference point: The drainage outlet of the water-filled quarry.

Reference level: The mean water table of the water-filled part of the quarry.

Öved-Ramsåsa Beds, layers 1*a*, 1*b*, 2 and 3 *sensu* Grönwall (1897). Grey shales and mudstones, occasionally silty and micaceous, thin beds of grey limestone (1*a*). Grey, biostromal limestone, bluish-grey micaceous, silty shale and mudstone (1*b*). Bj 70-1 KL, Bj 71-1 KL, -2 KL, -3 KL, Bj 74-4 KL, unnumbered PDL samples, unnumbered SMNH samples. MS 499, 500-508. Tentaculitids: *Lonchidium scanicum*, *Odessites portensis*, *Tentaculites hisingeri*, *T. obstipus*. Yellowish-white micaceous sandstone (2). Unnumbered PDL samples. Tentaculitids: None. Grey, silty shale (3). Unnumbered PDL samples. Tentaculitids: None.

References: Stobaeus 1741, Tab. 17; Retzius 1776, p. 84-85; Angelin 1877, p. 27, lines 10-11, 21-22; Tullberg 1882a, p. 24, bottom ten lines (*partim*) - p. 25, lines 1-25 (contains list of fossils), p. 29, lines 14-17; 1882b, p. 13, lines 27-29; Eichstädt 1888, p. 142, lines 27-29, p. 144, line 12 - p. 146, line 5 (contains list of fossils); Stolley 1896 p. 175, p. 177; Grönwall 1897, p. 22, line 22 - p. 26, line 7 (contains list of fossils); Thomé 1932, pp. 505-514, Figs. 1-2; Regnéll 1960, p. 30, 7 last line - p. 31, lines 1-5 (contains list of fossils); Martinsson 1967, p. 371, lines 14-15, p. 374, bottom four lines - p. 375, lines 1-5 (contains list of palaeocope ostracodes); Brood 1974, pp. 381-382, Fig. 1; Jeppsson 1974, p. 50.

Note: Layer 1*a* is not now exposed. Material from this layer is accessible in the large dump heaps occupying the NE and NW parts of the quarry.

BJÄRSJÖLAGÅRDBORRNINGEN 1, 617933 136818 (VB 1890 7645), ca. 2025 m NW of Ö. Kärrstorp church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Borehole located in the SE part of the quarry at Bjärsjölagård, at the edge of the quarry wall, close to the drainage outlet of the water-filled quarry. The borehole was drilled in 1967 by the Geological Survey of Sweden (SGU) and reached a total depth of 99.54 m below the surface. The well head was located approximately 113 m above mean sea level.

Reference level: The well head.

Öved-Ramsåsa Beds, layers 1*a* and 1*b* *sensu* Grönwall (1897). Main lithology and tentaculitids, see Fig. 70.

References: Skoglund 1968, Sorgenfrei 1969, Figs. 3, 5.

BJÄRSJÖLAGÅRDBORRNINGEN 2, 617924 136831 (VB 1900 7636), ca. 1850 m NW of Ö. Kärrstorp church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Borehole situated ca. 175 m SE of the drainage outlet of the water-filled quarry at Bjärsjölagård, immediately SW of the drainage ditch from the quarry and 50 m S of the junction of that ditch and the canal from Sjömossen. The borehole was drilled by the Geological Survey of Sweden (SGU) in 1967 and reached a total depth of 75.48 m. The well head was situated approximately 110 m above mean sea level.

Reference level: The well head.

Öved-Ramsåsa Beds, layers 1*a*, 1*b*, 2 and 3 *sensu* Grönwall (1897). Main lithology and tentaculitids, see Fig. 70.

References: Skoglund 1968, Sorgenfrei 1969, Figs. 3, 5.

KLINTA 1, 619519 135636 (VB 0691 9210), ca. 1550 m SSW of Bosjökloster church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section excavated in the cliff facing Ö. Ringsjön, 15 m SW of the shore line, ca. 340 m SE of the point where the small road passing Vrangelsborg becomes only a path (110 m down the path to the shore and then 210 m SSE).

Reference level: The base of the limestone bed 0.30-0.40 m above the base of the measured section in Jeppsson 1974, p. 49 (sample Kl 67-2 LJ).

Öved-Ramsåsa Beds, layer 2 *sensu* Eichstädt (1888). Grey marl and marlstone alternating with thin beds of grey limestone. Kl 67-2, -5, -6, -9, -10, -11 (all LJ), Kl 74-5, -6, -7 (all KL). Tentaculitids: *Lonchidium ogmotum*, *L. scanicum*, *Odessites portensis*, *Tentaculites hisingeri*.

References: Jeppsson 1974, p. 49; The following papers give references to the Klinta area in general and thus to all Klinta localities: Hisinger 1837a, p. 104; 1840, pp. 40-41; Murchison 1847; Angelin 1854, p. VIII; Erdmann 1872, p. 6; Angelin & Lindström 1880, p. 19-20, Pl 19:20-26; Tullberg 1882a, p. 13, lines 3-6, 11-19 (contains list of fossils); 1-82b, p. 12, lines 20-22, p. 13, lines 3-19 (contains list of fossils); 1883, p. 231, line 10; de Geer 1887, p. 21 bottom 20 lines - p. 22 lines 1-15 (contains list of fossils); Eichstädt 1888, pp. 133-141, p. 137, lines 17-31 description of layer 2; Grönwall 1897, pp. 16-20 (detailed description of the various layers at Klinta with lists of fossils); Törnebohm & Hennig 1904, pp. 54-55 (general description of the shore line at Klinta); Hadding 1929, pp. 191-192.

KLINTA 2, 619522 135632 (VB 0688 9214), ca. 1550 m SSW of Bosjökloster church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section excavated in the cliff facing Ö. Ringsjön, 20 m SW of the shore line, ca. 290 m SE of the point where the small road passing Vrangelsborg becomes only a path (110 m down the path to the shore, then 160 m SSE). The sections is situated at a small protruding part of the cliff.

Reference level: The base of the double limestone beds 4.96-5.12 m above the base of the measured section in Jeppsson 1974, p. 49 (samples Kl 67-21a and -21b LJ). Six small boreholes from geomagnetic sampling are noticeable in the lower of the two beds.

Öved-Ramsåsa Beds, layer 2 *sensu* Eichstädt (1888). Grey marl and marlstone alternating with thin beds of grey limestone. Kl 67-17, -20, -21a, -21b, -22, -23 (all LJ), Kl 74-3 KL. Tentaculitids: *Lonchidium ogmotum*, *L. scanicum*, *Tentaculites hisingeri*.

References: as for Klinta 1.

KLINTA 3, 619524 135630 (VB 0686 9216), ca. 1550 m SSW of Bosjökloster church. Topographical map sheet 2D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section excavated in the cliff facing Ö. Ringsjön, ca. 20 m SW of the shore line, ca. 260 m SE of the point where the small road passing Vrangelsborg becomes only a path (110 m down the path to the shore, then 130 m SSE).

Reference level: The base of the limestone bed 1.61-1.82 m above the base of the measured section in Jeppsson 1974, p. 49 (sample Kl 67-25 LJ).

Öved-Ramsåsa Beds, layer 2 *sensu* Eichstädt (1888). Grey marl and marlstone alternating with thin beds of grey limestone. Kl 67-25 LJ. Teutaculitids: None.

References: as for Klinta 1.

Note: Cores for geomagnetic investigations have been drilled in the marlstone beds 0.30-0.40 m above and 0.75-0.80 m below the reference level.

KLINTA 4, 619521 135635 (VB 0690 9211), ca. 1550 m SSW of Bosjökloster church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section excavated in the cliff facing Ö. Ringsjön, ca. 20 m SW of the shore line, ca. 325 m SE of the point where the small road passing Vrangelsborg becomes only a path (110 m down the path to the shore, then 190 m SSE).

Reference level: The base of the limestone bed 1.36-1.42 m above the base of the measured section in Jeppsson 1974, p. 49 (sample Kl 67-32 LJ).

Öved-Ramsåsa Beds, layer 2 *sensu* Eichstädt (1888). Interbedded grey marl, marlstone and grey thinly bedded limestone. Kl 67-31, -32, -33 (all LJ). Tentaculitids: *Lonchidium ogmotum*, *Odessites portensis*.

References: as for Klinta 1.

KLINTA 5, 619525 135627 (VB 0684 9220), ca. 1550 m SSW of Bosjökloster church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section excavated in the cliff facing Ö. Ringsjön, ca. 10 m SW of the shore line, ca. 225 m E of the point where the small road passing Vrangelsborg becomes only a path (110 m down the path to the shore, then 100 m SSE).

Reference level: The base of the limestone bed 4.55-4.64 m above the base of the measured section in Jeppsson 1974, p. 49 (sample Kl 67-2 LJ).

Öved-Ramsåsa Beds, layer 2 *sensu* Eichstädt (1888). Alternating beds of grey marlstone and grey, thinly bedded limestone. Kl 67-41 LJ, Kl 69-3 LJ. Tentaculitids: None.

References: as for Klinta 1.

KLINTA 6, 919530 135618 (VB 0669 9229), ca. 1550 m SSW of Bosjökloster church. Topographical map sheet 2D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section excavated in the cliff facing Ö. Ringsjön, ca. 15 m SW of the shore line, ca. 10 m S of the fence surrounding the southernmost cottage (110 m along the path to the shore from the point where the small road passing Vrangelsborg becomes only a path, then 30 m NNW).

Reference level: The base of the limestone bed 0.73-0.75 m above the base of the measured section in Jeppsson 1974, p. 49 (sample Kl 69-8 LJ).

Öved-Ramsåsa Beds, layer 1 *sensu* Eichstädt (1888). Alternating beds of grey marlstone and grey, thinly bedded limestone. Kl 69-8 LJ. Tentaculitids: None.

References: as for Klinta 1.

LUNNARNA 1, 619190 135612 (VB 0668 8891), ca. 2475 m NE of Gudmundtorp church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section along the canalized brook at Lunnarna, SW of the road between Snogeröd and Finnhult, ca. 925 m SSW of the outlet of the brook at Ö. Ringsjön. The section comprises 0-100 m SSW of the bridge.

Reference point: The southern side of the bridge.

Öved-Ramsåsa Beds, layer 1*a* *sensu* Grönwall (1897). Bluish-grey silty and micaceous shale. Lu 67-1 LJ, -4 LJ, -10 LJ, Lu 73-1 KL, unnumbered PDL sample. Tentaculitids: *Odessites inflatus*.

References: Martinsson 1967, p. 371, line 9; Jeppsson 1974, p. 49.

LUNNARNA 2, 619207 135613 (VB 0669 8908), ca. 2600 m NE of Gudmundtorp church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Section along the canalized brook at Lunnarna, 150 m N of the bridge on the road between Snogeröd and Finnhult, ca. 750 m SSW of the outlet of the brook at Ö. Ringsjön.

Öved-Ramsåsa Beds, layer 1*a* *sensu* Grönwall (1897). Bluish-grey silty and micaceous shale with intercalations of thinly bedded grey limestone. Lu AM-1, Lu AM-2. Tentaculitids: *Odessites inflatus*, *O. petilus*.

References: Martinsson 1967, p. 371, lines 5-8; Jeppsson 1974, p. 49.

RAMSÅSA 1, 616031 137920 (VB 3010 5755), ca. 450 m ESE of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Shallow exposure on the northern shore of Trydeån, 15 m NE of the sharp NW bend of the rivulent, immediately SW of the ruins of an old cottage. The exposure is only attained by digging.

Reference point: The SW point of the ruined cottage.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Dark brownish-red limestone in soft red mudstone and shale. Unnumbered PDL samples. Tentaculitids: *Lonchidium mobergi*, *Odessites lebiensis*.

Remarks: The locality is described as locality *A* by Grönwall (1897). Some material is now available from heaps of stone immediately S of the locality.

References: Grönwall 1897, pp. 30-32 (contains list of fossils); Moberg & Grönwall 1909, p. 8 (contains list of fossils); Jeppsson 1974, p. 50 (*partim*).

RAMSÅSA 2, 616035 137887 (VB 2978 5760), ca. 200 m SSE of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Heap of stone and stone fence immediately S of the SE corner of the cemetery. The material derives from the neighbouring fields.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Red limestone and reddish-greenish mottled limestone. Ra 71-3 LJ, unnumbered PDL samples. Tentaculitids: *Lonchidium mobergi*, *Odessites lebiensis*, *Tentaculites scalaris*.

Remarks: Grönwall originally described one locality, *B*, with stray boulders on the field some 300 m SSE of the church. The field continues S and SW of the cemetery and limestone boulders may today be collected from a stone fence running southwards from the cemetery towards the rivulet, especially close to the rivulet at 616025 137885 (VB 2975 5750). Most material stored in museum collections is labelled Ramsåsa A-B, and derives from the two localities originally described by Grönwall (1897) and the intervening field.

References: Grönwall 1897, pp. 32-33 (contains list of fossils); Moberg & Grönwall 1909, pp. 8-9 (contains list of fossils); Jeppsson 1974, p. 50 (*partim*).

RAMSÅSA 3, 616039 137849 (VB 2940 5763), ca. 350 m WSW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Former excavation at the intersection of a small ditch (running in a culvert) and a field road from the village of Ramsåsa to the abandoned quarry. The locality is immediately SW of where a small field road branches south from the road to the quarry. The locality is no longer accessible.

Öved-Ramsåsa Beds, layer 4 *sensu* Grönwall (1897). Red limestone and soft red mudstone. Unnumbered PDL sample. Tentaculitids: *Odessites lebiensis*, *Tentaculites loxus*.

Remarks: Locality *C* of Grönwall (1897). The fields around the locality now have stray boulders.

References: Grönwall 1897, p. 33 (contains a measured section); Moberg & Grönwall 1909, p. 9 (contains a measured section).

RAMSÅSA 4, 616031 137851 (VB 2940 5756), ca. 375 m SW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Shallow exposure on the eastern side of a small rise W of the westernmost field road running southwards from the village of Ramsåsa to the rivulet ca. 120 m N of Trydeån.

Öved-Ramsåsa Beds, layer 4 *sensu* Grönwall (1897). Reddish-brown soft mudstone and red thinly bedded limestone. Ra D_1 67-1, -2, -3, -4 (all LJ). Tentaculitids: *Lonchidium mobergi*, *Odessites lebiensis*, *Tentaculites scalaris*.

Remarks: The locality is the first outcrop described by Grönwall (1897) under his locality *D*. Subsequently Jeppsson (1974) designated this outcrop locality D_1.

References: Grönwall 1897, p. 34, lines 1-3; Moberg & Grönwall 1909, p. 9, bottom two lines - p. 10, lines 1-2; Jeppsson 1974, pp. 50-51, locality D_1.

RAMSÅSA 5, 616030 137849 (VB 2939 5755), ca. 390 m SW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Shallow exposure at the southern side of a small rise immediately W of the westernmost field road from the village of Ramsåsa to the rivulet ca. 100 m N of Trydeån. The locality is ca. 20 m SW of Ramsåsa 4.

Öved-Ramsåsa Beds, layer 4 *sensu* Grönwall (1897). Soft red mudstone. Unnumbered PDL samples. Tentaculitids: *Tentaculites loxus*.

Remarks: This is the second outcrop described by Grönwall (1897) under locality *D*. Jeppsson (1974) designated it D_2.

References: Grönwall 1897, p. 34, lines 3-15 (contains list of fossils); Moberg & Grönwall 1909, p. 10, lines 2-11 (contains list of fossils); Jeppsson 1974, pp. 50-51, locality D_2.

RAMSÅSA 6, 616029 137845 (VB 2935 5755), ca. 440 m SW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Shallow exposure on the SW slope of the small rise W of the westernmost field road from the village of Ramsåsa to the rivulet. The locality is ca. 70 m W of Ramsåsa 4.

Öved-Ramsåsa Beds, layer 4 *sensu* Grönwall (1897). Reddish-brown silty mudstone. Ra D_3 67-1, -2, -3, -4 (all LJ). Tentaculitids: None.

Remarks: Grönwall's (1897) third exposure under locality *D*, and described as the locality where Lundgren (1874) and Linnarsson (1875) obtained their Ramsåsa material. Jeppsson (1974) designated it D_3.

References: Lundgren 1874, p. 8, line 22 - p. 14; Linnarsson 1875, p. 280, lines 9-24 (contains list of fossils; Grönwall 1897, p. 34, bottom nineteen lines - p. 35, lines 1-26 (contains list of fossils); Moberg & Grönwall 1909, p. 10, lines 12-34; Jeppsson 1974, pp. 50-51, locality D_3.

RAMSÅSA 7, 61603 13784 (VB 293 575), ca. 500 m SW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Small abandoned and now destroyed, quarry approximately halfway between Ramsåsa 6 and Ramsåsa 8.

Öved-Ramsåsa Beds, layer 4 *sensu* Grönwall (1897). Reddish-brown, silty mudstone and micaceous siltstone. Unnumbered PDL samples. Tentaculitids: None.

Remarks: Locality *E* of Grönwall (1897). The small quarry for grindstones was already filled and covered with vegetation at the time of Görnwall's paper.

References: Nilsson 1842, p. 77; Grönwall 1897, p. 35, bottom six lines - p. 36, lines 1-2; Moberg & Grönwall 1909, p. 10, bottom four lines.

RAMSÅSA 8, 616026 137830 (VB 2922 5753), ca. 580 m SW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Abandoned and largely filled quarry on the northern slope towards Trydeån, ca. 100 m N of the rivulet, ca. 175 m NW of the westernmost bridge over Trydeån.

Öved-Ramsåsa Beds, layer 4 *sensu* Grönwall (1897). Reddish-brown sandstone with intercalations of red shale and some thin beds of red limestone. Ra 67-3 LJ, Ra 71-1 KL, unnumbered PDL samples. Tentaculitids: *Lonchidium groenwalli*, *L. mobergi*, *Odessites lebiensis*, *Tentaculites scalaris*.

Remarks: Grönwall's (1897) locality *F*. Today only layers *n* to *r* are accessible.

References: Lundbohm 1891, p. 24; Grönwall 1897, pp. 36-39 (contains measured section and a list of fossils); Moberg & Grönwall 1909, pp. 11-13, lines 1-7 (contains measured section and a list of fossils); 1929, p. 192, line 16 - p. 193, lines 1-5 (contains a measured section); Lehman 1937, 98 pp.; Regnéll 1960, p. 31, lines 15-16; Lindström 1960, p. 330; Jeppsson 1974, p. 51.

RAMSÅSA 9, 616027 137762 (VB 2855 5752), ca. 1220 m WSW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Small exposure immediately east of the westernmost small subsidiary brook to Trydeån, where the powerline crosses the brook, ca. 75 m N of Trydeån. The locality is no longer accessible but is covered by dumped material.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Reddish-brown mudstone and thin beds of reddish-brown limestone. Ra G 66-2 LJ. Tentaculitids: *Lonchidium mobergi*, *Tentaculites scalaris*.

Remarks: Locality *G* of Grönwall (1897). The locality was reported by Grönwall and later by Moberg & Grönwall (1909) as poorly exposed because of material dumped there from the surrounding fields.

References: Moberg 1888, map; Moberg 1893, p. 15, lines 3-8; Grönwall 1897, pp. 39-40; Moberg & Grönwall 1909, p. 13; Jeppsson 1974, p. 51.

RAMSÅSA 10, 61602 13775 (VB 285 575), ca. 1300 m WSW of Ramsåsa church. Topographical map sheet 1 D Ystad & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Surface exposure on the southern side of a small rise immediately E of the railway cut in Precambrian rocks at Fyledal. The exposure is no longer accessible.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Reddish-brown mudstone. Ra H 66-1 LJ, unnumbered PDL sample. Tentaculitids: *Tentaculites loxus*, *T. scalaris*.

Remarks: Locality *H* of Grönwall (1897). The exact position is difficult to determine because of a prolific cover of vegetation.

References: Moberg 1893, p. 17, bottom 3 lines; Grönwall 1897, pp. 40-41 (contains list of fossils); Moberg & Grönwall 1909, p. 13 (contains list of fossils); Jeppsson 1974, p. 51.

RAMSÅSA 11, 616041 137761 (VB 2854 5765), ca. 1200 m WSW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Temporary excavation and small surface exposures in the slope ca. 15 m W of the westernmost small brook running to Trydeån, ca. 225 m N of Trydeån. The locality is only accessible by digging.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Reddish-brown soft mudstone. Unnumbered PDL samples. Tentaculitids: None.

Remarks: The locality is designated Ia by Moberg & Grönwall (1909).

References: Moberg & Grönwall 1909, p. 16, lines 18-37.

RAMSÅSA 12, 616038 137764 (VB 2857 5764), ca. 1175 m WSW of Ramsåsa church. Topographical map sheet 1 D Ystad & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Temporary excavation and small brook section along the westernmost small brook running to Trydeån, ca. 200 m N of Trydeån and at the point where the power line crosses the brook. The locality is now only accessible by digging.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Reddish-brown soft mudstone. Unnumbered PDL samples. Tentaculitids: *Lonchidium groenwalli*, *L. mobergi*, *Odessites lebiensis*, *Tentaculites scalaris*.

Remarks: Locality Ib of Moberg & Grönwall (1909). They made a 6.7 m excavation from which abundant material is available in the collections of the Palaeontological Department at Lund. The material is labelled "Jakob Pers" together with a number designating the sampled bed.

References: Moberg & Grönwall 1909, pp. 15-16 (contains list of fossils).

RAMSÅSA 13, 615939 137774 (VB 2867 5661), ca. 1550 m SW of Ramsåsa church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Temporary excavation in the steep of forested slope, ca. 100 m N of the abandoned brickworks south of Fylan.

Öved-Ramsåsa Beds, layer 1 *sensu* Grönwall (1897). Grey shale and limestone. Unnumbered PDL sample. Tentaculitids: *Odessites inflatus*.

Remarks: Moberg & Grönwall (1909) designated this locality as *K*. A trench was dug in the loose scree halfway up the slope and the bedrock surface was reached at a depth of one metre. Material from the excavation is available at the Palaeontological Department at Lund.

References: Moberg & Grönwall 1909, p. 18, lines 10-37 (contains list of fossils); Moberg 1910, p. 139, bottom two lines - p. 140, lines 1-8 (contains list of fossils).

RÖDDINGE 1, 61628 13757 (VB 276 600), ca. 450 m SSW of Röddinge church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 142 Sövdeborg.

Temporary excavations on the SW slope of the small triangular plateau, Lerberget, immediately S of Röddinge. The bedrock is only accessible by digging.

Colonus *Shale*. Grey to dark grey, silty, micaceous shale with some thin beds of limestone. Unnumbered PDL samples. Tentaculitids: *Dicricoconus tenuissimus*.

Remarks: Three trenches were excavated by Moberg in 1907 along the SW slope of Lerberget, and rich material is still available in the collections of the Palaeontological Department at Lund. The locality was designated no. 17 and was comprehensively described in Moberg & Törnquist 1908 and Moberg & Grönwall 1909.

References: Moberg & Törnquist 1908, pp. 4-13; Moberg & Grönwall 1909, *Loc 17*, pp. 23-26; Moberg 1910, p. 139, lines 5-21; Hadding 1929, p. 190, line 14; Hede 1958, p. 68, lines 2-9; Regnéll 1960, p. 30, lines 1-5; Martinsson 1967, p. 368, lines 30-32.

SKARHULT 1, 608856 134806 (UB 9867 8543), ca. 1025 m E of Skarhult church. Topographical map sheet 2 C Malmö NO. Geological map sheet Aa 92 Lund.

Exposure at the bottom of Bråån, ca. 225 m E of the small road bridge over Bråån, ca. 475 m ESE of the easternmost tower of the castle at Skarhult. The locality is only accessible at low water.

Colonus *Shale*, lower-middle part. Grey shale with intercalations of thin limestone beds. Sk AM-1, Sk LM-1. Tentaculitids: *Dicricoconus tenuissimus*, *Odessites geretiensis*.

References: Hede 1919b, pp. 113-160 (contains description of fossils); Hadding 1929, p. 190, line 13; Hede 1958, p. 68, lines 12-25; Regnéll 1960, p. 30, lines 5-11; Martinsson 1967, p. 368, lines 20-30 (contains list of palaeocope ostracodes); Jeppsson 1974, p. 7.

SKARTOFTA 1, 617770 136438 (VB 1508 7477), ca. 2375 m NNW of Öved church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Temporary drainage ditch section in field, 35 m S of the ditch-road intersection, 30 m SW of the 90° bend of the road between Skartofta and Tullesbo. The section is no longer accessible, but dumped material from the excavation lies immediately south of the 90° bend at 617771 136441 (VB 1510 7478), 20 m N of the ditch.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Grey shale and mudstone with thin intercalations of grey limestone. Sk 68-1 LJ, Sk 76-1 KL. Tentaculitids: *Lonchidium mobergi*, *Tentaculites scalaris*.

References: Jeppsson 1974, p. 50. The following papers give reference to the Skartofta area in general: Hisinger 1828, p. 188; Angelin 1854, p. VIII; Tullberg 1883, p. 231.

SKARTOFTA 2, 617767 136465 (VB 1535 7477), ca. 2400 m NNW of Öved church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Well digging in the SW corner of the schoolyard, 10 m NW of the road between Skartofta and Tullesbo, 50 m SSW of the westernmost of the cluster of houses W of Tullesbo.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Grey shale and mudstone with thin intercalations of grey limestone. Ra 68-2 LJ, -4 LJ, -5/6 LJ. Tentaculitids: *Lonchidium groenwalli*, *L. mobergi*, *Odessites lebiensis*, *Tentaculites scalaris*.

References: as for Skartofta 1.

SKARTOFTA 3, 617770 136487 (VB 1556 7477), ca. 2500 m NNW of Öved church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 86 Övedskloster.

Low section in the pond immediately south of the road between Skartofta and Tullesbo, 150 m W of the crossroads W of Tullesbo.

Öved-Ramsåsa Beds, layer 3 *sensu* Grönwall (1897). Grey shale and lenses of grey limestone. Sk 68-7 LJ. Tentaculitids: None.

References: as for Skartofta 1.

SMEDSTORP 1, 616022 139172 (VB 4263 5763), ca. 1300 m WSW of Smedstorp church. Topographical map sheet 1 D Ystad NO & 2 D Tomelilla SO. Geological map sheet Aa 190 Simrishamn.

Low section along the ditch running NW of the small road between Smedstorp church and Ljungstorp. ca. 50 m S of the ditch - powerline intersection.

Colonus *Shale*, *P. ludensis* zone. Dark grey shale. Unnumbered PDL samples. Tentaculitids: None.

References: Holst 1892, p. 36, bottom four lines - p. 37, lines 1-6; Hede 1915, 65 pp. (loc. *a*), (detailed description of fauna and lithology); Regnéll 1960, p. 26, lines 10-14 from the bottom; Laufeld *et al.* 1975, pp. 215, 217, 218, 219, and 220.

VRANGELSBORG 1, 629555 135581 (VB 0630 9256), ca. 1500 m SW of Bosjökloster church. Topographical map sheet 2 D Tomelilla NV. Geological map sheet Aa 92 Lund.

Well digging on the shore, ca. 150 m W of Vrangelsborg.

Öved-Ramsåsa Beds, layer 5 *sensu* Eichstädt (1888). Soft grey mudstone and shale with occasional thin beds of grey limestone. Vr 66-4 LJ. Tentaculitids: *Lonchidium groenwalli*, *Tentaculites scalaris*.

References: Jeppsson 1974, pp. 49-50.

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